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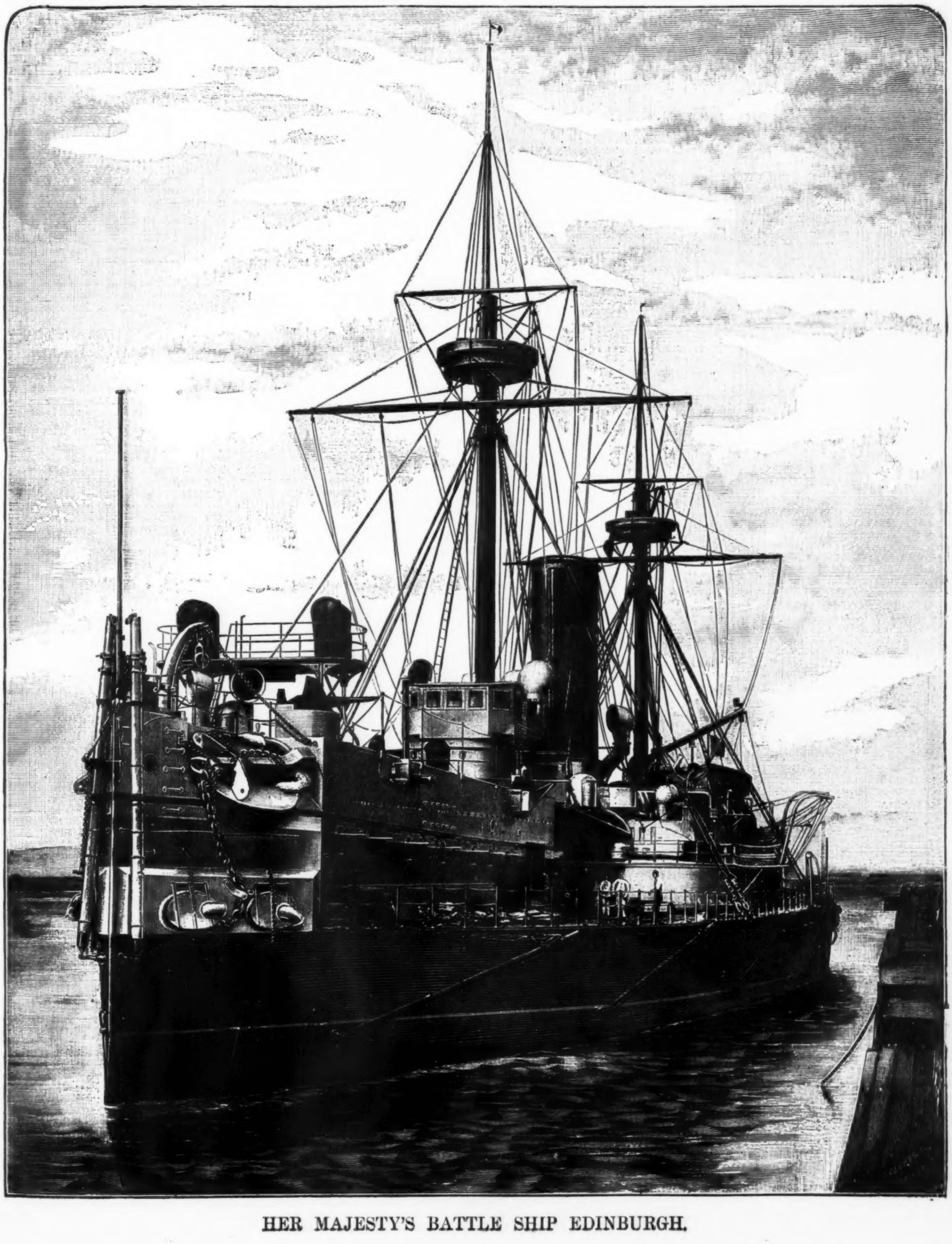
THE BRITISH BATTLE SHIP EDINBURGH.

In our Supplement No. 697 we gave illustrations and particulars of this remarkable vessel, to which the reader is referred. We now present a bow view of the ship. The Edinburgh has a displacement of 9,150 tons, engines 7,500 h. p., speed 16 knots, length 325 ft., beam 68 ft., draught 26 ft. 3 in., armament four 47 ton 12 in. guns, five 6 in. steel guns, twenty-two quick-firing machine guns, also torpedoes, etc. Her revolving turrets have armor 16 in. thick, citadel 18 in. thick. Her cost was $3,225,000.



HER MAJESTY'S BATTLE SHIP EDINBURGH.

SHIP CANALS IN 1889.*

By R. E. PEARY, C.E., U.S.N.

COMPLETED ship canals abroad number 12 in all, with a total length of nearly 500 miles, as follows:

The Languedoc canal, known also as the "Canal du Midi," is often spoken of as a ship canal, though its dimensions do not justify such a classification. Its claim to the name seems to be in the fact that it was built for the use of the ships of that time (seventeenth century) engaged in the coasting trade between the Atlantic and the Mediterranean shores of France, and that for its time it was undoubtedly as great an undertaking as the Suez canal in recent years.

It forms a communication between Bordeaux and the Bay of Biscay and Cette and the Mediterranean. Its length is 140 miles, summit level 610 ft. above the Mediterranean, depth 6 ft. 7 inches, and it has 119 locks. The canal was completed in 1681 at a cost of $7,20),000.

The Caledonian canal extends from Inverness Firth, on the east coast of Scotland, to Loch Eil, on the west coast, a distance of about 60 miles, 38 of which are occupied by a chain of lakes. Early in the century, Telford, at the request of the English government, reported upon the project and was intrusted with the execution of the work, which was commenced in 1804 and completed in 1823. The government was led to build this canal by the expectation that it would save vessels a long and dangerous circuit by the Pentland Firth, where, previous to the introduction of steam, they were liable to be detained for weeks by contrary winds, and also that in time of war the canal would afford a convenient refuge for merchant vessels from privateers and a means by which war vessels might pass rapidly from one sea to the other.

The canal was designed for vessels of 20 ft. draught, and it has 28 locks, 170 ft. × 40 ft. × 8 ft. lift. The width on the bottom is 50 ft., on the surface 120 feet., and depth 20 ft. The summit level is 100 ft. above the sea, and the cost of the work was about $5,000,000. It was a bold and skillful undertaking, but it has not been a success financially.

Wars hindered its progress, and finally, to save expense, the summit cut was not carried to full depth, and will permit the passage of vessels of only 17 ft. draught. Had the full depth of 20 ft. been obtained the canal would have admitted vessels of 1,000 tons, and probably to this fact more than any other may be attributed its failure in a financial sense.

North Holland Canal.—The difficult navigation of the Zuider Zee, formerly the only means of access to the port of Amsterdam, decided the Dutch government early in the present century to make an artificial route for the maritime trade of that city. The shortest line from Amsterdam to the North Sea, in a westerly direction, was then considered out of the question, on account of the difficulty of maintaining an entrance on the exposed flat coast of the North Sea, and a northerly route through North Holland to the Texel Roads was adopted.

The canal built on this route is known as the North Holland, and was commenced in 1819 and finished in 1825, at a cost of $5,000,000. It is 52 miles long, 123½ ft. wide at the surface, 31 ft. wide at the bottom, and 18⅛ ft. deep. It has a double tide lock at each extremity, with chambers 237 ft. × 51 ft. and 82 ft. × 18½ ft., and three regulating locks.

This canal was of great value to Amsterdam, and was of unusual magnitude for the time when it was constructed. It has lost its importance since the completion of the Amsterdam canal.

The Crinan canal, nine miles long and twelve feet deep, across the peninsula of Kintyre, enables vessels of 160 tons to save a voyage of about 70 miles round the Mull of Kintyre.

Gloucester-Berkeley Canal.—An act was obtained in 1793 for connecting Gloucester by a direct ship canal with the estuary below, and after much delay the canal was completed by Telford in 1827. It is 16½ miles long and 18 ft. deep. At the lower end, where it enters the Severn, there is a tide lock.

The Witham canal, which gives Boston a direct communication with the sea, available for vessels of 2,000 tons, is one of the most important of recently completed English works of its class. The canal is three miles long and 27 ft. deep, 130 ft. wide on the bottom, and cost, with some accessory works, $1,000,000.

The St. Louis canal was constructed to avoid the bar of the river Rhone. It extends from the Rhone above the bar to the Mediterranean east of the Rhone outlet. It is 2 miles long, 206 ft. wide at low water level, and 19½ ft. deep.

The Gota canal gives direct water communication across Sweden from the North Sea to Stockholm, a distance of about 300 miles. The canal proper, however, is but a series of short links connecting a chain of lakes which occupy four-fifths of the distance. The canal is 46 ft. wide on the bottom, 86 ft. on the surface, and 10 ft. deep. It has 76 locks and the summit level is 300 ft. above the sea. About 10,000 craft pass through the canal annually.

Suez Canal.—The value of a channel of communication between the Mediterranean and Red Seas, through the Isthmus of Suez, is evident from a glance at a map, saving as it does a long voyage around the Cape of Good Hope for maritime traffic between Europe and the southern coasts of Asia.

The idea of the construction of such a canal originated in remote antiquity. It is said that a canal across the isthmus existed in the time of Sesostris, 1600 B. C., which later was abandoned. Nero and Darius both contemplated constructing a canal here, and Harcourt states that there is evidence that a canal for small vessels was opened and maintained from about 600 B. C. to 800 A. D., but was subsequently allowed to fall into decay.

Louis XIV. of France had a proposition submitted to him to construct a canal, and Napoleon gave the project very serious consideration, but was deterred from carrying it into execution by the erroneous results of his engineers' surveys, these surveys showing that the level of the Red Sea was ten meters above that of the Mediterranean.

In 1847 the figures were shown to be wrong, and accurate surveys demonstrated that the mean level of the two seas was the same.

In 1854 M. De Lesseps obtained the concession for the canal, but the inauguration of the work did not take place until Aug. 25, 1859. Work really began in earnest the following year, and Aug. 15, 1869, the waters of the two seas mingled in the Bitter Lakes.

Nov. 17 of the same year, the canal was formally opened and traversed by a numerous fleet of vessels of all nations. The canal extends from Port Said on the Mediterranean, at sea level, and without locks, across the isthmus by the most direct route, which carries it through the depression of Lakes Menzallah, Ballah, and Timsah, and the Bitter Lakes, to Suez on the Red Sea, in a line nearly due north and south. Its length is 99 miles, its width varies at the surface from 196 ft. to 328 ft., according to the strata through which it is excavated, but the bottom width is 72 ft. throughout. The depth is 26 ft. Through a portion of the Bitter Lakes, no excavation was necessary, and the deepest cut, at El Guisr, was only 85 ft. to the bottom of the canal. The amount of excavation was about 98,000,000 cubic yards, mostly sand and clay or a mixture of both, except at places south of the Bitter Lakes, where some rock was encountered. The cost of the canal was about $100,000,000.

From the day the Suez canal was opened its business increased steadily and rapidly up to 1877, when it amounted to 1,663 vessels annually. In the two following years the traffic decreased, owing to a general depression in trade; then it went up with a jump, more than doubling in amount from 1879 to 1882, and grew rapidly through 1883, when it amounted to 3,307 vessels of a net tonnage of 5,775,861 tons, or say 6,000,000 tons. With this amount of traffic, it became apparent that the capacity of the canal with original dimensions and only 14 *gares* was practically reached, and it was evident that speedy and simple measures must be taken to increase its capacity.

Two projects were discussed—one to build a second canal alongside the original one, another to widen and deepen the present canal. The latter project was approved in the beginning of 1885, and the canal is to be enlarged to a depth of 29·5 ft. and a width, 26 ft. below the surface, of from 213 ft. to 246 ft. on tangents, and 246 ft. to 262 ft. on curves of less than 5 mins. radius. The total amount of excavation requisite to complete this enlargement is estimated at 91,000,000 cubic yards and the estimated cost is about $41,000,000.

The first stage of this work, which will give a depth of 27·8 ft., is now in progress, to cost about $12,000,000. Pending its completion the traffic of the canal since 1883 has increased very slowly, although the canal has been opened to night traffic, reducing the time of transit from 36 hours to 16 hours, and the increase has been more in the way of an increased average tonnage per vessel than in the number of vessels. This increase in the average vessel tonnage is very instructive. In 1870 the average was 1,000 tons; in 1886 it was 1,863 tons. With the completion of the enlargement, the traffic of the canal will undoubtedly take another vigorous bound upward.

The financial success of the canal can be best judged by the value of its shares. On ordinary shares the canal paid in 1886 over 11 per cent., and on preferred shares nearly 17 per cent. A year ago ordinary shares of $100 sold in London at $427.50 and in Paris at $434.

Commercially this canal is of more importance to England than to any other country, as it shortens the voyage to her Indian possessions about 7,000 miles, as compared with the voyage around the Cape of Good Hope, and about 75 per cent. of the traffic of the canal is British. Strategically also it is of vital importance to England, and, as events have already shown, in case of complications she will possess and hold it at all hazards.

The Amsterdam canal, which the circuitous route by the North Holland canal and the increasing size and draught of the vessels trading to Amsterdam forced that city to construct in order to hold its own against the more favorably situated ports of Rotterdam and Antwerp, extends due west from Amsterdam across the peninsula of Holland to the North Sea, a distance of 15½ miles. Its bottom width is 88½ ft., its surface width 187 ft., and its depth 23 ft. The greater portion of it was constructed through a shallow lake, and the remainder through low sand dunes.

The principal difficulties in its construction were the formation and maintenance of the entrance on the North Sea and the complete rearrangement of the system of drainage of the region traversed by it. This drainage is now pumped into the canal at the North Sea, and there is a double lock, as on the North Holland, with chambers 390 ft. × 60 ft. × 227 ft. × 40 ft. At the Zuider Zee end there is a triple lock, with one chamber 315 ft. × 60 ft. and two 238 × 47 ft.

In the construction of the canal and harbor 21,000,000 cubic yards of sand were removed by dredging, much of it costing only 2*d.* per cubic yard. The canal was commenced in 1865 and completed in 1876, at a total expenditure of nearly $15,000,000.

The canal is doing a large and increasing traffic, as many as 700 vessels having passed through its double locks in one day, to the great benefit of Amsterdam.

The plan for the St. Petersburg canal was matured in 1872–73, but work was not commenced until 1878. It was partially opened in October, 1884, and finally completed and formally opened by the Czar and Czarina, May 27, 1885.

The length of this canal is 18 miles, with a maximum width of 350 ft. and a general width of 180 ft. to 240 ft., depth 22 ft. The cost of the canal was about $9,000,000. The canal starts from the mouth of the Neva, where it opens into a large basin, and after joining the canal to Cronstadt meets the Neva above St. Petersburg. The excavation amounted to about 63,000,000 to 70,000,000 cubic yards of easily worked material, clay, sand, and gravel, most of it used in construction of the embankments.

The personnel and plant employed upon the canal consisted of 3,500 men, 13 dredgers, 3 locomotives, with 230 cars, 86 lighters and barges, 12 tugs, and 7 stationary engines.

This canal has both strategical and commercial importance from opening up communication for war ships and large vessels of all kinds directly with St. Petersburg. Previous to the construction of the canal, the cargoes of all vessels drawing over 9 ft. had to be lightered 20 miles up the river to St. Petersburg, and all goods for export had to be lightered down the river in the same manner. The effect of this canal was to increase the exports of St. Petersburg from 280,000 tons in 1883 to 950,000 tons in 1886, but it was at the expense of Cronstadt, the commerce of which was practically destroyed.

Ghent-Terneuzen Canal.—Beginning as far back as 1251, several canals have been constructed to maintain the communication of Ghent with the sea, the last one having been completed in 1827. The distance from Ghent to the sea by this canal was only 21 miles, as compared with 105 miles by the river Scheldt. It, however, proved inadequate for the constantly increasing size of vessels since its construction, and it has recently been straightened and enlarged to a width of 173 ft. and a depth of from 20 ft. to 22 ft., with results most beneficial to Ghent.

Completed canals at home are four in number, with a total length of about 40 miles.

The Welland canal extends from Lake Erie to Lake Ontario, parallel with and west of the Niagara River. The length is 27 miles, bottom width 100 ft., depth 14 ft. It has 27 locks, with a total lift of 330 ft., and will pass vessels of 1,000 tons.

The canal was begun in 1824 and finished by private parties in 1833, the depth being 8 ft. In 1841 it was assumed by the Canadian government and its enlargement to 9 ft. depth commenced. Still later the depth was increased to 10 ft. by raising the embankments, and the locks were enlarged to correspond. In 1867 the canal was capable of passing a 400 ton vessel, and it had cost up to that time about $7,500,000.

In 1871 it became apparent that it would be necessary to again increase its capacity, and the work of enlargement was commenced soon after and completed in 1887. It was intended at first that this enlargement should consist of an increase in the depth of the canal to 12 ft. and a corresponding increase in the rise of the locks, but almost as soon as the work was commenced, it was seen that this would not be sufficient, and the depth was increased to 14 ft. A further enlargement is very likely to be undertaken in the not far distant future.

The St. Mary's canal, which forms the outlet of Lake Superior, is unique in several respects. It is one mile long, has a depth of 16 ft., and has the largest lock in the world, 515 ft. × 80 ft. × 18 ft. lift.

This canal was originally constructed in 1855 with two locks, each 350 ft. × 70 ft. × 9 ft. lift. About 1870 it became evident that the capacity of the canal had been nearly reached, and the work of enlargement was undertaken. This consisted of the construction of the present lock and the deepening of the canal to 16 ft.

These improvements were completed in 1881, at a cost of about $2,500,000, with a most astonishing result upon the traffic of the canal.

The number of vessels increased, and their size and draught increased to correspond with the larger waterway. The tonnage of the canal increased from 1,500,000 tons in 1881, the first year of the enlarged canal, to 4,500,000 tons in 1886, *i. e.*, it trebled in five years. In 1888 the tonnage was over 5½ million tons. From 1885 to 1886 the total tonnage increased 37 per cent., and from 1887 to 1888 the average tonnage per vessel increased some 20 per cent. The annual tonnage of the canal is now very nearly as great as that of Suez, 1,685 vessels having passed through the canal in one month.

In 1886 it was seen that the capacity of the canal would be reached in two or three years, its ultimate capacity being 96 vessels per day of 24 hours, and 84 having already passed in that time, and a still further enlargement was proposed and is now in progress. This will consist of a lock 800 ft. × 100 ft., with a depth of 21 ft. on the sills and a lift of 18 ft., and the deepening of the canal to 20 ft.

The new lock is to be placed upon the site of the two old ones, and will be used with the present new one. The cost of the enlargement is estimated at $4,738,865, and the time 5 years. If, on its completion, the traffic of the canal takes such a bound upward as after the last enlargement—and there is no reason to doubt that it will—Suez, even with its enlargement completed, will have difficult work to keep pace with it.

The present lock in this canal is undoubtedly the finest, as it is the largest, in the world. It is manipulated entirely by hydraulic power furnished by the fall at the lock, and the operation of hauling in, locking, and hauling out a vessel is easily accomplished in 13 minutes. The cost per ton of passing vessels through the canal was in 1882–83, 1½ cents to 2 cents. It is now about one-half cent.

The Des Moines canal gives a passage around the Des Moines rapids of the Mississippi River. Its length is 7·6 miles, width 300 ft., depth at extreme low water, 5 ft., and at high water, 16 ft. and 26 ft. The locks are 350 ft. × 80 ft. The total cost of the canal was about $4,500,000. In 1885 about 1,000 vessels passed through this canal.

The Louisville and Portland canal, around the falls of the Ohio, at Louisville, is a work similar to the Des Moines canal. In 1885, 5,000 vessels, of a total tonnage of 1,217,231 tons, passed the canal.

Canals now in process of construction abroad are three in number, with a total length of 99 miles.

The Corinth canal will cut the isthmus of the same name, uniting the waters of the Ægean Sea and the Gulf of Lepanto. The ancients, Periander, tyrant of Corinth, in 628 B. C., Demetrius, Polyorcetes, one of the successors of Alexander the Great, Cæsar, and Caligula had all seen the commercial advantages and importance of a canal at this point, and Nero actually undertook the execution of the project, and the evidences of his work, after the lapse of 18 centuries, are perfectly distinguishable, and show the measure of the human force that this emperor had at his disposal.

There was a great demonstration at the inauguration of this work, and Nero turned the first sod with a golden spade, in approved modern style. He is said to have abandoned the project upon being informed by scientists that the sea was higher on one side of the isthmus than on the other.

In 1881 a French company was organized, with a capital of $6,000,000, M. De Lesseps being honorary president. Three routes were surveyed across the isthmus, and the one finally selected was the same as the ancient one of Nero.

May 4, 1882, the work was inaugurated, the King of Greece turning the first sod with a silver spade, and the Queen firing a train of dynamite mines. The line of the canal is perfectly straight, and its total length is 4 miles.

It was expected that the canal could be finished in 4 years, and a contracting firm took the job for $5,280,000; but inaccurate estimates as to the amount and

* Abstract of paper read by R. E. Peary, C.E., U.S.N., at the Seabright convention of the American Society of Civil Engineering.—*Engineering News.*

quality of rock to be excavated, the necessity for flattening the side slopes, and the corresponding increase of excavation have greatly prolonged the work and increased the expense.

It is now expected that the canal will be completed in 1890 or 1891. The total cost is variously estimated at from $9,000,000 to $12,000,000.

The canal as completed will be 4 miles long, with a depth of 28 ft., a surface width of about 92 ft., and a bottom width of 52 ft. The depth of the cut at the highest part of the isthmus will be 288 ft.

The personnel and plant employed upon the canal have of course varied with the progress of the work, but at the maximum have been about 3,000 men, 15 locomotives, 700 cars, 6 or 8 dredgers, with their attendant tugs and barges. The maximum day's work has been 8,000 c. m.

The total amount of excavation in the canal will be about 8,500,000 c. m., a large portion of which is so-called rock. Up to the end of last year something over 5,000,000 c. m. had been removed. The work on this canal has been especially interesting from the various systems of attacking the great mass of excavation that have been successively tried.

This canal will shorten the voyage of vessels going from the Adriatic Sea to Turkey and Asia Minor by 185 miles, and those going through the Straits of Messina by 95 miles. It is estimated that the annual tonnage making use of the canal will be 4,500,000, and the tolls for vessels from the Adriatic will be 20 cts. per ton, and those from the Mediterranean, 10 cts.

North Sea and Baltic or Holstein Canal.—Considering the auspices under which it is to be constructed, and the principal incentive to its inception, this canal will probably be the most commanding work of its kind in Europe.

The project for a ship canal between the Baltic and the North Sea dates back about 40 years. There are, however, three small canals now in existence between the two seas, one of which was completed in 1398; another was constructed in 1525; and the third, which is 10½ ft. deep, was finished by King Christian of Denmark in 1785.

In 1878 the ship canal project was brought forward in a vigorous manner, first by private parties and then by the government, which gave the entire subject careful legislative consideration during 1881-83, and finally approved the bill in June, 1886. June 3, 1887, the German emperor officially inaugurated the canal, and only last month proposals for some 15,000,000 cu. yds. of further excavation were advertised for by the imperial commission of Kiel.

All the projects for the canal having originated in military and political considerations, the same considerations controlled the selection of the final route from the important naval station of Kiel on the Baltic to Brunsbüttel, the deep water at the mouth of the Elbe, from among some 16 proposed locations. The canal is to be a through cut, and its length will be between 60 and 61 miles; the usual radii of curves 4,900 ft. and 6,500 ft., with a minimum of 3,275 ft. The chief value of the canal being in the speed with which it can be traversed, the curves will be as easy and as few as possible.

The deepest cut will be 82 ft. to the water surface. The average cross section of the canal will be 85 ft. 3 in. wide at bottom, 197 ft. at water surface, and 28 ft. deep, giving 3,930 sq. ft. of prism, which will permit the ordinary Baltic vessels to pass without trouble.

Special sidings and the lakes will accommodate war vessels. The depth will probably be increased to 29½, and future increase in width is provided for. At the North Sea end, there will be three tidal locks, 275 ft. × 41 ft., 412 × 82 ft., and 1,180 × 196 ft. respectively, and at the Baltic end a single large lock, all of massive construction and worked by hydraulic power.

The total amount of excavation is 67,000,000 cu. yds. and the estimated cost of the canal $39,000,000. Of this sum, $12,500,000 represents the excess cost of the work as a military canal over what it would cost for purely commercial uses.

The commercial advantages of the canal are the saving in distance, time, pilot dues, and loss in going around Denmark. The saving in distance by vessels running from the south and west of London to the Baltic is 237 miles, and from German ports some 425 miles. The saving in time is from 30 hours for steamers to 4 days for sailing vessels. The greater safety is also an important item, 200 vessels being annually lost in the dangerous passage from the North Sea to the Baltic.

The North Sea-Baltic traffic is variously estimated at from 36,670 to 40,600 vessels annually, with a registered tonnage of 12,240,000 tons, 9,210,000 to 5,500,000 tons of which would use the canal at a toll of 18¾ cts. per registered ton. The great feature of the canal, however, is its military importance, allowing the German fleet to be concentrated either in the North Sea or the Baltic.

The Manchester canal, now in process of construction, will make the city of Manchester, at present 50 miles from the sea, and 35 miles from the head of the tidal estuary of the Mersey, practically a seaport, and will completely alter the destination of an immense amount of tonnage now entered or cleared at London, Hull, and especially Liverpool.

It is said that the scheme for connecting Manchester with the sea dates back to 1712. In 1882 the matter was taken up vigorously by the local authorities and capitalists of Manchester. The first project considered was to deepen and widen the channel, so as to make a tidal waterway from the bar of the Mersey to the Manchester docks, a distance of 50 miles. Thorough surveys and studies led to the rejection of this project and the adoption of the present plan on which the canal is being built, made by Mr. Williams, C.E.

Opposition from various interests delayed the passage of the canal bill in Parliament for several years, and it was not until the summer of 1887 that this opposition was overcome and the bill finally passed.

The capital of the company was immediately raised, and the contract for the construction of the canal given out the same year. Work was commenced at once, and is now being vigorously pushed, so that there seems to be no doubt that the canal will be finished within the contract time of four years, or by Jan. 1, 1892.

The length of the canal is a trifle over 35 miles from Manchester to the Mersey estuary, separated into two divisions.

First, a tidal division extending 12 miles through the Mersey estuary and 8 miles inland, with a bottom width of 100 ft. and a depth of 26 ft. at low tide.

Second, a canal division 15½ miles long, with the same width and depth. There are four locks, or rather series of locks, these locks being built in groups of three, of different sizes, and with intermediate gates, so that any size of vessel may be passed without waste of water. The total rise of the canal is 60 ft.

The total amount of excavation is about 48,000,000 cu. yds. and the contract price for the work is $30,-000,000.

The personnel and plant now engaged upon the canal is about as follows, viz.: 15,000 men, 70 steam shovels, 50 steam cranes, 150 locomotives, 5,000 dump cars, etc., and an average of over 1,000,000 cu. yds. per month are being taken out.

The figures of the expected traffic of the canal I am unable to give, but there seems to be no question that it will be a financial as well as an engineering success, there being a very dense manufacturing population within a radius of a few miles of Manchester, to which supplies must be brought, and from which manufactured products must be taken away.

Canals in progress at home are five in number, with a total length of 191 miles.

The project for the Cape Cod canal was broached a little over 200 years ago, and nearly 100 years ago complete surveys had been made for the work. It is only within a few years, however, that work has actually been commenced, and it has not progressed very rapidly.

The length of the canal is 7·6 miles, and the deepest cut is only 25 ft. to high water level. The proposed section of the canal is 200 ft. wide and 23 ft. deep at low water. The amount of material to be excavated is about 18,000,000 cu. yds. and the cost is variously estimated at from $3,000,000 to $9,000,000 The time for construction was put at from three to five years. Two miles of the canal are stated recently to be finished to a depth of 15 ft.

This canal would shorten the route from Boston to parts south from 70 to 140 miles, and the saving in time for sailing vessels is estimated at an average of three days. The expected traffic of the canal is put at 4,000,000 to 5,000,000 tons.

The military advantages of the canal are as great as its commercial ones.

The Columbia canal will connect the Congaree and Broad Rivers, S. C. It is 5 miles long, 10 feet deep, and 150 ft. wide. Over a mile of the canal, including the most difficult portion, is already completed. The canal will give Columbia and the Broad River a water outlet to sea at Charleston.

The Cascades canal, around the Cascades of the Columbia River, will be 3,000 ft. long and will have two locks, 462 × 80 and 90 ft., with 8 ft. to 24 ft. of water. This canal will give an outlet to the great plain of the Columbia, as yet almost entirely undeveloped.

The Harlem canal, which is to connect the East and North Rivers by way of Harlem River and Spuyten Duyvel Creek, will be about 8 miles long, 15 ft. deep, and 400 ft. wide. The history of this work dates back to 1874, when Gen. Newton made a survey for the canal. In 1879 Congress appropriated $400,000 for the work, and in 1887 proposals were advertised for, and the contract awarded in December of the same year. The work was commenced early in 1888, and is now in progress. The estimated cost is $2,700,000.

Nicaragua Canal.—The birth of the idea of a ship canal across the Central American isthmus is practically coincident with the discovery of the New World, for it sprang into existence the moment it was proved that there was no natural strait connecting the two seas. But, though the project was frequently discussed and numerous so-called reconnaissances made, there was nothing like an accurate survey of a route until within the present century. As soon as the Central American colonies threw off the Spanish rule and gained their independence, the Nicaragua route came prominently to the front.

In 1850-51, a thorough survey of a complete route from the Atlantic to the Pacific was made by Col. O. W. Childs, and plans and estimates presented for a canal 50 ft. wide at the bottom, from 78 ft. to 118 ft. wide at the surface, and 17 ft. deep, the estimated cost being a little less than $33,000,000.

Col. Childs' work is of interest as being the first survey made anywhere on the American isthmus which was really deserving of the name, all previous ones being wholly or in part based upon mere reconnaissance, estimate, or even hearsay. A commission which examined Col. Childs' plans came to the conclusion that a canal of the proposed dimensions would not meet the requirements of ocean-going vessels, nor could it see at that time sufficient prospective traffic to make the canal a financial success, and consequently the project was dropped.

When the United States government in 1870-75 undertook, through the Navy Department, its comprehensive system of exploration of the American isthmus from Tehuantepec to the head waters of the Atrato, to determine the best route for a canal, the Nicaragua route was one of the first surveyed. Captain Lull, in command of the expedition, presented plans for a ship canal with a bottom width of 50 to 72 ft., a surface width of 106 to 165 ft., and a depth of 26 ft. Estimated cost a little less than $66,000,000.

In 1876 and 1880 Civil Engineer Menocal, U. S. N., the engineer of Capt. Lull's survey, revised portions of the route, and in 1885 radically modified the eastern portion. In the spring of 1887 a concession was obtained from Nicaragua by American capitalists for the construction of a canal, and in the latter part of the same year a large and thoroughly equipped engineering force was sent to Nicaragua to thoroughly resurvey and definitely locate the line of the canal.

Plans and estimates for a canal with a bottom width of from 80 ft. to 120 ft., a surface width of 80 ft. to 340 ft., and a depth of 30 ft., based upon this final location, were prepared in the latter part of 1888. The estimated cost was about $66,000,000 and the time for completion five years. Last February Congress passed the bill incorporating the company, and the work of construction has already been commenced.

The total distance from sea to sea is 170 miles; less than 30 miles of this distance, however, is actual canal, the remainder being lake, river, and lagoon navigation. The summit level is 154 miles long and 110 ft. above the sea. There are six locks. The principal features of this canal are the creation of 64 miles of slack water in the San Juan River by means of a dam, and the formation of several miles of lagoon navigation by impounding the surface drainage by a series of earthen embankments. The estimated time of traversing the canal is 28 hours, and the estimated traffic, when first opened, at not less than 6,000,000 tons annually.

The magnitude of the benefits resulting from the opening of this canal it would be impossible to overstate. It will shorten the commercial water routes of the world from 1,200 to 6,000 miles, and the routes between our own eastern and western seaboards by 8,000 miles.

Exceptional as has been the success of the Suez and St. Mary's canals, the Nicaragua canal has all the favoring circumstances of both in an enhanced degree. The Suez canal opened a shorter route to comparatively fully developed countries, and its effect was simply to divert to itself, from longer routes, a traffic already existing. The St. Mary's canal is the only outlet of a region the development of which has been rendered possible by the canal itself. The Nicaragua canal will open a direct route to regions which, although they already yield a traffic of 6,000,000 tons per annum, may be said to have just begun to develop, and the canal will not only divert this existing traffic to itself, but will *create* a business the proportions of which it is impossible to estimate. When the traffic of the St. Mary's canal climbs from 1,500,000 tons in 1881 to 4,500,000 tons in 1886, as the result of the development of the region about Lake Superior, some idea may be formed of the future traffic of a canal which will be to the Pacific Ocean what the St. Mary's canal is to Lake Superior, its only outlet.

Projected canals abroad number some 17, with a total length of about 2,000 miles. Five of these projects are English.

Birmingham.—The rivalry between the great English manufacturing centers, greatly intensified by the construction of the Manchester canal, will doubtless result, in the near future, in the construction of similar work for the benefit of Birmingham, Sheffield, Bristol, etc. Judging, however, from the numerous projects which have been advanced within the past two or three years for giving Birmingham a canal communication with almost everywhere, that city feels the rivalry and the disadvantages of its inland position most keenly, and is likely to be the first to follow the example of Manchester. The principal projects so far are: a barge canal to the Trent; ship canal to London, estimated cost $5,000,000; a ship canal to the Mersey, to cost $8,000,000; and a ship canal to the Severn, estimated cost, $6,250,000. The latter project seems now in a fair way to be put through. The outgoing traffic of Birmingham is stated at 2,000,000 tons annually.

The Great Western canal would be in reality a prolongation of the Birmingham canal in the interest of the commercial and manufacturing centers tributary to the Bristol Channel. The projected route is from Stalford on the Bristol Channel via Taunton to Seaton, a distance of 62 miles. The canal is to be 125 ft. wide at the surface, 36 ft. wide at the bottom, 21 ft. deep. Estimated cost, $15,000,000. It will save a voyage of 300 miles around Land's End.

The Newcastle-on-Tyne canal project, to connect the Tyne with the Solway Firth, first talked of some fifty years ago, was again brought forward about five or six years since, and some work done in the way of surveys. The distance from sea to sea is 80 miles, of which some 12 miles are now navigable by vessels of large size. It is claimed that the canal would offer a convenient short cut for ocean steamers from one coast to the other. Within the past year a project for a Scotch canal from the Clyde to the Forth has been talked of. Its length would be 35 miles and the rise 156 ft. There is at present a 9 ft. canal along the route, and it is said there would be no great engineering difficulties to overcome. Estimated cost from $7,500,000 to $10,000,000. This canal, it is claimed, would be of great benefit to vessels plying from the west coasts of the British Isles to the North and Baltic Seas; would open the coal and oil districts of Scotland; and would possess important military advantages in permitting the rapid concentration of war vessels on either coast.

The project for an Irish canal between Galway and Dublin attracted some attention in England in 1883-84. It was proposed to enlarge the existing canal to a width of 100 ft. on the bottom and 200 feet on the surface, to admit the passage of the largest steamers. The length is 127 miles, and there were to be 30 locks. A preliminary estimate of cost was $250,000,000. Further studies reduced this to $100,000,000. Alternative plans to accommodate vessels of 2,500 and 1,500 tons were estimated at $60,000,000 and $40,000,000 respectively. It was claimed that by using this canal, transatlantic steamers to ports on the Irish Sea would save 1,000 miles of sea voyage and one day's time. A press comment upon the project at the time was that the "scheme is not much more visionary than the Manchester canal."

The Bay of Biscay-Mediterranean canal project, which comes up every now and then in France, would be practically an enlargement of the Languedoc canal. One of the proposed routes would follow closely that of the present Languedoc canal from Bordeaux to Narbonne. The other starts on the Bay of Biscay at Archacon, south of the mouth of the Gironde, and runs northeasterly to the valley of the Garonne and thence to Narbonne. The total distance is 267 miles. The canal will be 120 ft. to 147 ft. wide, and 25 ft. to 27 ft. deep. The summit level will be 557 ft. above the sea, and the locks will have lifts of 30 ft. and over. The deepest cut will be 163 ft. The estimated cost is $130,000,000, and the canal would save a voyage of 700 miles around Spain.

The North Sea-Mediterranean canal project is a most remarkable one. Like most other great enterprises of this character, its conception is not new, but dates back to the beginning of the Christian era. It seems to have first taken definite shape about ten years ago in a plan for a canal from Marseilles to Lyons, and thence to Dunkirk. A second route was from Marseilles to Lyons and thence to Paris and Rouen. The portion of this last route from Paris to the English channel seems likely to be constructed at a not distant date, a French company having offered within the year to execute the work at its own expense, if it is granted a toll of 60 cents per ton on all vessels entering the canal above Rouen.

The proposed canal would be 20 ft. deep, and extend along the Seine from Rouen to Paris, 112 miles.

Brussels Canal.—The city of Brussels is agitating the project of deepening her present 10 ft. canal to the sea, built in 1836, to a depth of 21 ft. to 22 ft., to admit vessels of 2,500 to 3,000 tons, at an estimated cost of $4,000,000 to $6,000,000.

The Bruges canal, it is expected, will restore the old time commercial prestige and importance of Bruges, which has been completely destroyed by the silting up of its communication with the sea. Its length will be 7½ miles, depth 23 ft., and estimated cost about $5,000,000.

The Paris-Boulogne canal is intended for vessels of 600 to 800 tons, depth 13 ft.

Surveys for an Italian canal, to extend from Fano on the Adriatic to near Castro on the Mediterranean, were made about a year ago. The length of the canal would be about 180 miles; the estimated cost is $100,000,000 and the time for completion five years. It is claimed that this canal would be of great value to the whole of southern Europe.

Baltic-Black Sea Canal.—Within the past five or six years this project for a ship canal from the Danube near Vienna, through Moravia, Austrian and Prussian Silesia to the Oder near Breslau, has attracted considerable attention. The distance in an air line is 200 miles and the estimated cost of a canal capable of passing large war vessels is put at about $37,000,000. The project has been reported as entirely feasible and it is said that a preliminary credit for conducting the surveys has been applied for. It is claimed that the number of vessels using the canal would be three times as great as the number at Suez.

The Don-Volga or Black Sea-Caspian canal will extend from Serepta on the Volga to Tzaritzine on the Don, a distance of 53 miles. It will pass vessels of 500 to 600 tons, and the estimated cost is $14,000,000, not including administration, discount, etc. The total excavation is about 35,000,000 cu. yds. and the deepest cut is 128 ft.

The Perekop canal will cut the Isthmus of Perekop, the link between the Crimea and the mainland, and unite the Gulf of Perekop and the Sea of Azof. It will be 70 miles long and 12 ft. deep, and the estimated cost is $40,000,000. It is thought that it can be completed in four to five years, and it is claimed that it will shorten the voyage between Odessa and Sea of Azof ports 295 to 434 miles, and greatly benefit the salt, mineral, grain, and fuel producing districts of southeastern Russia. A company is said to be now prepared to build the canal.

The Jordan or Palestine canal project was quite prominent in England in 1883. It was proposed to cut a canal 25 miles long, from Acre on the Mediterranean to the valley of the Jordan north of Lake Tiberias, and a second one, 67 miles long, from the Gulf of Akabah to the south end of the Dead Sea valley, and then flood these valleys, forming a lake about 147 miles long and 10 miles wide.

The total distance from sea to sea would be 240 miles, and the estimated cost was from $40,000,000 to $100,000,000. The origin of this project was entirely English, and it was undoubtedly only agitated for the purpose of obtaining better terms for English interests at Suez.

A very general project for a Syrio-Persian canal from the Mediterranean to the Persian Gulf, via Antioch, the Orestes and Euphrates, Babylon, Bagdad, and the Tigris, was presented to the French Academy of Sciences in 1886–87. It was claimed this canal would shorten the Indo-European voyage three days.

The Isthmus of Malacca canal project was vigorously agitated by the French in Siam in 1882–83, and M. De Lesseps asked the King of Siam for a concession. The canal would connect the Bay of Bengal with the Gulf of Siam near Kraw. Its length would be 66 miles; the estimated cost is $20,000,000, and it is claimed it would save 500 miles of dangerous navigation on voyages from New York or Liverpool to China ports.

The Ceylon-Indian canal project contemplates a canal through the island of Ramisseram, lying between Ceylon and India, by which it is said a sea voyage of 300 to 400 miles would be saved.

Projected canals at home number about 12.

Panama Canal.—The idea of a canal at Panama is of equal antiquity with that at Nicaragua. The two projects may be said to be twins. The first actual survey of the Panama line seems to have been made in 1828, but nothing came of it. In 1843–44 M. Napoleon Garella surveyed a line across the isthmus, and a French company was organized and preparations made to commence the work, but wars in Europe interfered, and the project fell through.

In 1875 a line was surveyed across the isthmus by Capt. Lull, under orders from the United States navy department, and plans and estimates made for a lock canal. In 1876–77 Lieuts. Wyse and Recluse, of the French navy, surveyed several lines, and in March, 1878, Lieut. Wyse obtained a concession from the Colombia government. A company was then formed, with M. De Lesseps at its head, to construct the canal, and after the preliminary arrangements were completed, the formal inauguration took place in February, 1881.

Several plans for this canal were discussed, viz., with locks, with a tunnel, and a through cut, the last plan being finally adopted. The length of the canal is 47 miles, and the proposed depth 26 ft. The deepest cut is 386 ft., and the total amount of material to be removed was estimated at first at 46,000,000 c. m., later at 105,000,000 c. m., and still later at 151,000,000 c. m., which last is probably still below the mark.

The original cost of the canal was $120,000,000, the time of completion eight years, and it was expected that 6,000,000 tons of traffic would use the canal annually. Under the stimulus of M. De Lesseps' wonderful energy and great prestige the stock of the company was rapidly taken; great quantities of plant and material were shipped to the isthmus; a magnificent "installation" was put in operation; and the work went merrily on. Almost at the outset, however, obstacles, which had been pointed out by prominent engineers, were encountered, and the work did not progress as rapidly as had been expected.

Several additional issues of bonds were made without dampening the enthusiasm, until in 1886 many intelligent people, who had hitherto believed in the project, became doubtful as to its success. This feeling increased and became general among all classes in 1887, when it was shown conclusively that about $150,000,000 had already been expended and only one-fifth the amount of excavation completed, and that the company could now raise money only at a heavy discount. To meet this exigency the plans were changed "provisionally" to a lock canal with ten locks, to be gradually lowered to sea level after the canal was opened.

This change in plans very materially reduced the amount of work yet to be done, and was not without its effect in renewing confidence in the minds of some. This effect, however, soon wore off, and after a series of desperate financial moves to raise money last summer, among others a grand lottery scheme, the failure of the company to float an additional issue of bonds, even at a ruinous discount, gave the project its deathblow, and after numerous struggles it collapsed finally and completely during the past winter, with obligations amounting to over $450,000,000, and after having expended some $250,000,000 in cash. The total result of this expenditure is the removal of a cube of some 50,000,000 c. m., or about one-third the total amount. The laborers employed in the work have been sent home by their respective governments, and the Panama canal is a thing of the past.

As an engineering work it has not been especially interesting, as none of the real engineering problems connected with its completion have been touched. It is, however, interesting as showing the results of starting into a great project without sufficient or accurate information; and more particularly the blind infatuation with which the "ipse dixit" of a single successful man may be followed against all the facts and reasoning in the world. It may be taken for granted that this canal will never be completed.

Delaware-Chesapeake Canal.—During 1879–82 the government surveyed three principal routes for a ship canal to connect Chesapeake and Delaware Bays, and since then the project has been more or less prominently before the public, and a company was formed to construct the canal, but as yet no work has been done.

Of the three routes surveyed, the one known as the Sassafras is the favorite. The length of the canal by this route is 30 miles, from bay to bay, of which distance 14 miles will be obtained by widening and deepening streams, and 16 miles will be through. The proposed section of the canal is bottom width 90 ft., surface width 171 ft., depth 27 ft. No locks except tide locks. The cost is variously estimated at from $6,500,000 to $11,500,000, and the time for completion four years.

The canal would save 215 miles between Baltimore and New York, and other eastern and European ports, and 286 miles between Baltimore and Philadelphia. It is anticipated that the canal would attract at least three-fourths of the tonnage of Baltimore, or between 5,000,000 and 10,000,000 tons. From a military point of view, this canal would be of great importance.

Niagara Falls Canal.—Several surveys and plans for a ship canal from Lake Erie to Lake Ontario have been made within the past thirty years, and two powerful causes push the project to the front every now and then:

1. The very natural desire to have a canal of our own between those lakes.

2. The fact that the Welland canal, with its 14 ft. depth, is not deep enough to accommodate modern lake traffic, a fact which will be doubly emphasized when the improvements at St. Mary's and St. Clair have been completed, and a depth of 20 ft. obtained.

A recent project is for a canal 20 ft. deep to accommodate vessels of 3,000 tons. The length is about 25 miles, and the estimated cost $18,000,000. This canal seems more than likely to become an accomplished fact in the not distant future.

A Florida ship canal project has been more or less continuously agitated during the past ten years or more, and in 1883–84 it looked as if the work would be actually undertaken. A charter was obtained, a company organized, and surveys made, but nothing came of it.

Starting from the St. John's River, just above Jacksonville, the canal would cut across to the Suwanee River on the Gulf coast. Its total length would be 137½ miles, the deepest cut 143 ft. for a short distance, and the proposed dimensions were, width 230 ft., depth 30 ft., sufficient to permit 3,000 ton vessels to pass without sidings. It was expected the canal would be completed in three years, and the estimated cost was $46,000,000.

The canal would enable vessels to avoid the navigation of the straits of Florida and would save in distance between New York and New Orleans 500 miles; New Orleans and Liverpool, 412 miles; New York and Pensacola, 600 miles.

Delaware-New York Bay Canal.—This project contemplates enlarging the Delaware and Raritan canal sufficiently to permit its use by large vessels.

This canal, with the Cape Cod canal, the canal from the Delaware to Chesapeake Bay, and the Dismal Swamp and Florida canals, would form a grand inland system of navigation, which would offer an almost air line route to the coasting trade between Boston, New York, Philadelphia, Baltimore, Norfolk, the Carolina sounds, and Gulf of Mexico. Such a system could not be duplicated in either hemisphere nor its commercial and military importance be overestimated.

The military aspect of this project has recently been made the subject of a very instructive report by Admiral Luce, U.S.N., in which he points out the facilities such a canal would offer for the rapid concentration of war vessels at any point for defense or offense, and the complete bar it would present to any effectual blockade of any of our great bays or ports.

Other home projects, including some in the earliest embryo stage, some of at present doubtful importance, and some in regard to which it has been impossible to learn much more than the name, are as follows:

The Lake Borgne canal, from Lake Borgne to the Mississippi River, length 12 miles, estimated cost $450,000, will, it is claimed, save the coast trade east of New Orleans a voyage of 265 miles.

The St. Clair-Lake Erie canal would connect those two bodies of water through Canadian territory.

A Cincinnati-Lake Erie canal has two routes proposed, one from Cincinnati to Toledo, and one via Zanesville to Cleveland. A preliminary estimate of cost of enlarging present canals is about $28,000,000.

Surveys for the Fresno-San Joaquin River canal are said to have been made, and the canal will enable steamers to run through from San Francisco. Estimated cost, $3,000,000.

The Lower Michigan canal will extend from Saugatuck to Detroit, via the Kalamazoo River, a distance of about 178 miles. Its depth will be sufficient to pass vessels of 1,500 tons, and it will have six or eight locks. Estimated cost, about $5,500,000. This canal would give an almost air line route from Chicago to New York, and save several hundred miles in distance.

The Upper Michigan canal will connect Bay Autrain, on Lake Superior, with Little Bay De Noquet, on Lake Michigan. Its length is 36 miles; it would have two locks, and the estimated cost is about $5,000,000. This canal would reduce the voyage between Duluth and Chicago 271 miles, and if the Lake Superior trade increases during the next decade as it has during the past the canal will be a necessity, and there will be ample business for both it and St. Mary's.

Regarded simply as engineering works, maritime canals may be divided into two great classes—those with locks and those without. A classification based upon the causes which lead to the inception and execution of such canals would be something as follows:

Commercial canals, originating in the demand of cities or regions unfavorably situated by nature for an outlet for their products, or in the struggle between rival cities or states for commercial precedence, or even existence, as the Manchester, St. Mary's, and Amsterdam canals.

Military canals, originating in a nation's military exigences or ambitions, as the Holstein canal.

Inter-ocean canals, originating in the imperative demands of the world's commerce, as the Suez and Nicaragua canals.

Inter-ocean canals are the highest class. Aiding no one nation at the expense of another, they benefit every country that owns a ship. There are but two locations for such canals, one in each hemisphere, Suez and Nicaragua. One is completed, the other is in process of construction.

After making all allowance for the fashion set by the completion of the Suez canal, and the added impetus given by the commencement of work on the Panama canal eight years ago, to all kinds of projects for ship canals, many of which the recent catastrophe at Panama will cause to drop out of sight, we may rest assured that the ship canal has come to stay and to become a powerful commercial and political factor. The next few decades are sure to see wonderful results in this direction.

The completion of the Nicaragua canal will leave no more worlds to conquer in the class of inter-ocean canals; but the impetus it will give to commerce in general, together with the already active tendency in the direction of maritime canals to give inland ports a direct and unobstructed communication with the sea, will probably for a time concentrate the activity in ship canal construction in works of that class. The completion of many of these, and the continued growth of ocean commerce and its ever-increasing demand for shorter routes, will then result in the construction of canals similar to the Corinth, Isthmus of Malacca, and Delaware-New York Bay canals, until every sea and ocean route will have been reduced to its minimum length.

And it may not be a very wild flight to anticipate the time when every maritime nation of importance will have, as one of the most important adjuncts of military offense and defense, its ship canal for the rapid concentration of its huge floating fortresses at different parts of its coast.

THE FORT MADISON BRIDGE ACROSS THE MISSISSIPPI.

THE second most important bridge on the line of the Chicago, Santa Fe and California Railway (Atchison, Topeka and Santa Fe extension), from Kansas City to Chicago, is at the crossing of the Mississippi River near Fort Madison, Iowa. This road was built in 1887, and, it being desired to complete the bridge in eight months, the chief engineer, Mr. A. A. Robinson, organized a special department, and placed Mr. O. Chanute in charge as consulting and executing engineer.

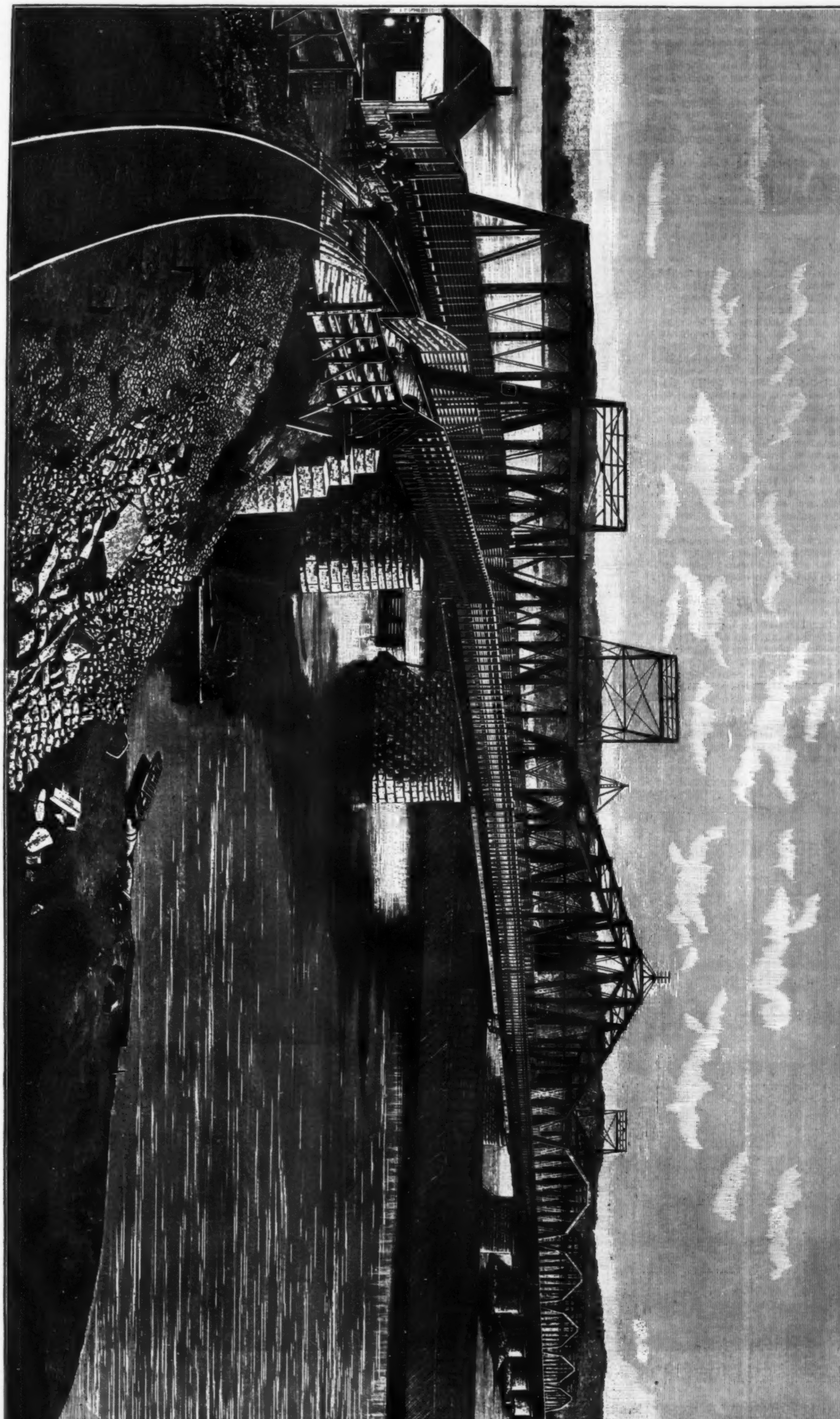
The Mississippi River, at Fort Madison, is about 1,500 feet wide at low water, and this, together with a part of the adjoining sandbar, was covered by the following arrangement of spans (see engraving), counting from the Fort Madison side:

	Feet.
One span on curve 530 feet radius	150
" " " " "	150
" draw span, over all	400
" raft span	275
" river span	237½
" " "	237½
" sandbar span	237½
" " "	237½
Total length of iron bridge	1,925

In addition to which there is a further opening of 1,300 feet of trestle work resting upon piles, across the sandbar, on the Illinois side of the river.

The work was begun in April, and the first train crossed over the bridge on December 8, 1887, or a little less than eight months thereafter. The spans are all "through spans," the lower chord being some 10 feet above high water, or about 30 feet above low water. The masonry was built of magnesian limestone of excellent quality, and both this and the foundations were executed by the firm of Sooysmith & Co. The foundations presented no unusual difficulty, but there was a good deal of variety in their requirements. On the Fort Madison side, the river flows over tough blue clay, and in this, bearing piles were driven, cut off a foot or two above the clay, and upon them were sunk wooden caissons on which the masonry was built. Beyond the fourth foundation, however, the clay dipped and was overlain with sand. Foundations Nos. 5 and 6 were therefore put down by the plenum pneumatic process and carried 10 feet and 34 feet, respectively, through the sand to the clay, thus attaining a depth of 28 feet and 50 feet below low water.

Beyond this, again, the clay was out of reach, borings to a depth of 127 feet failing to find it. Bottomless caissons were accordingly put down through the sand to a depth of 16 feet to 20 feet, and bearing piles were driven inside of these, and cut off close to the surface of the sand. Upon these piles caissons were lowered in the usual way, inside of which the masonry was built. In all cases the weight was limited to 18 tons



BRIDGE OVER THE MISSISSIPPI RIVER, NEAR FORT MADISON, IOWA; ATCHISON, TOPEKA, AND SANTA FÉ EXTENSION RAILWAY.

MR. O. CHANUTE, ENGINEER, THE UNION BRIDGE COMPANY, NEW YORK AND PENNSYLVANIA, CONTRACTORS.

per pile, or about one-eighth of their ultimate resistance.

The superstructure was erected by the Union Bridge Company, of New York, and for the sake of expedition the work was divided between their shops at Buffalo, New York, and Athens, Pennsylvania. Iron was chiefly used, but the webs of the floor girders, and some of the chords, were of Scotch steel, specially rolled and imported, it having been found cheaper and quicker to place the order in Great Britain than in the United States.

The cost of the bridge was £130,000, this providing a single track iron bridge and two carriage roadways, one on each side, 8 feet wide, so as to acommodate the farmers on the Illinois side of the river. Screens of thin wooden slats separate the carriage roads from the railway, and prevent the horses from seeing the passing trains. This arrangement has thus far been found to work well.

The superstructure was proportioned to carry two locomotives, coupled, weighing each 70 tons, and followed by a train of 3,000 lb. per lineal foot. With this loading the stresses are limited to 8,000 lb. per lineal foot, and the bridge presents an unusually massive appearance.—*Engineering.*

ARMOR PLATE.

THE idea of covering ships with metal impenetrable to projectiles is more ancient than is generally supposed. Strabo tells us that in the third Punic war, the Carthaginians constructed a hundred and twenty armor-clad vessels. In the 12th century, the Normans protected certain portions of their vessels with plates; later on the Knights of St. John of Jerusalem fitted out armor-clad caracs for the siege of Tunis; and Andre Doria imitated them in the 16th century. Finally, we may cite the floating batteries of Chevalier d'Arcon constructed for the siege of Gibraltar, and the planking of which was strengthened by means of iron bars in order to arrest the round and solid projectiles—the only kind in use at the time.

But it must be remembered that the firing of cannon was still very uncertain even at the beginning of the present century, and that, as regards naval artillery, it is only in the long period that began in 1815 that the material and methods have been improved.

The use of the bridge, of the sight, of the hammer, and of fulminating quick-matches, and the simultaneous introduction of the cartridge and projectile into the gun, rendered the firing of artillery more accurate, more rapid, and consequently more dangerous. Yet, it may be admitted that had not guns been profoundly modified, ships would never have been overloaded with heavy and costly armor plate.

But a new engine of destruction had come upon the scene. At the moment in which the steam navy was making its first steps, General Paixhan, of the artillery, invented the shell, and, as long ago as 1822, predicted that, in order to resist its incendiary effects, the ship would necessarily have to be barred with iron. The general was not mistaken; the immense progress of metallurgy was to demonstrate that the idea that he had emitted, and that had found nothing but unbelievers, would be applied in every navy in less than forty years after the advent of the shell. With the sailing vessel, it would have remained in the domain of Utopia; with the steam navy, it has revolutionized the art of battling on the sea.

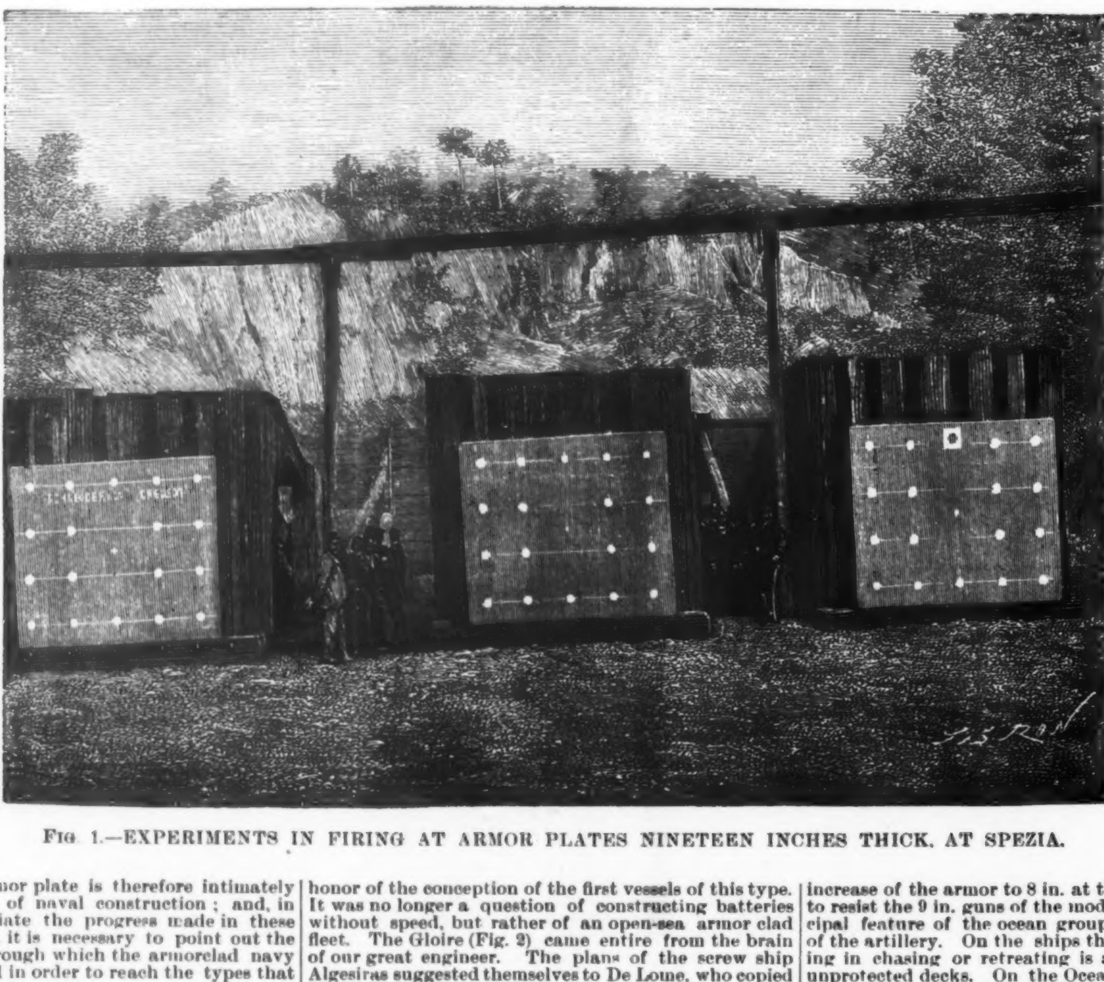


FIG 1.—EXPERIMENTS IN FIRING AT ARMOR PLATES NINETEEN INCHES THICK, AT SPEZIA.

The history of armor plate is therefore intimately connected with that of naval construction; and, in order to well appreciate the progress made in these protective coverings, it is necessary to point out the successive stages through which the armorclad navy has so rapidly passed in order to reach the types that are now constructed.

When the illustrious Dupuy de Lome decided on the plans of the screw steamer Napoleon, one of the most beautiful specimens of naval art known, the necessity of protecting the sides of ships against the ravages of the shell was a subject of discussion in maritime circles. Vessels were no longer merely menaced with being sunk through breaches made by round balls, or of being dismasted by the latter, but the shell, on exploding in the batteries, spread death therein and caused grave fires. A few unfortunate blows, and the finest vessel might be disabled, if not destroyed. It was then felt that it was necessary to find a means of protecting it

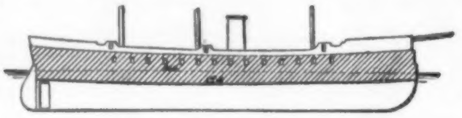


FIG. 2.—GLOIRE.

against the bursting of powder shells, just as to-day the necessity is felt of protecting it against shells filled with powerful explosives.

Impressed with this necessity of vertical protection, Dupuy de Lome, in 1845, proposed to construct a steam frigate covered with superposed plates forming a thickness of 6⅓ inches. The council of naval works rejected the project, and it took nothing less than the Crimean war and the demonstration that a wooden

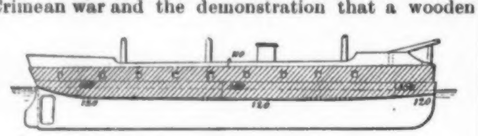


FIG. 3.—FLANDRE.

fleet was thenceforward powerless to reduce well constructed fortifications, to cause the first armorclads to be constructed, in 1854. These were the five floating batteries, Devastation, Tonnante, Lave, Foudroyante, and Congreve—very ordinary sea vessels covered with a 4⅓ inch iron armor from the Creusot works.

The first three of these vessels, on the 17th of October, 1855, reduced the fortifications of Kinburn in a few hours. The balls from the Russian fortress broke on

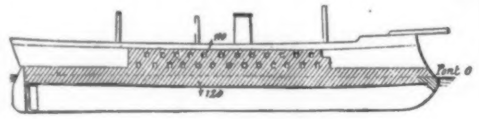


FIG. 4.—SOLFERINO.

their sides, and made but insignificant impression thereon. In reality, these floating batteries, with their flat bottoms and very full forms, were true floating forts—that is all. Their speed was scarcely more than four knots, they sailed badly and were handled with difficulty.

Nevertheless, the experiment was decisive, and the armor-clad sea vessel was to make its advent without delay. It is again to Dupuy de Lome that is due the honor of the conception of the first vessels of this type. It was no longer a question of constructing batteries without speed, but rather of an open-sea armor clad fleet. The Gloire (Fig. 2) came entire from the brain of our great engineer. The plans of the screw ship Algesiras suggested themselves to De Lome, who copied the hull of it and cut down the high battery in order to find the weight of the armor. This latter was 5 inches at the load line, and was reduced to 4⅓ at the top sides, which it covered for their entire extent. The Gloire was 252 feet in length, and displaced 5,618 tons—a large figure for the epoch. Her speed on trial was 12 31 knots. Her first armament was 36 six-inch rifled guns, for which were afterward substituted 6 nine-inch guns and 3 seven and a half inch (model of 1864).

Almost at the same time, the Couronne was put on the stocks. This was an iron frigate of 6,330 tons, of which the armor was 4 inches at the load line and 3¼ at the battery. The Couronne still exists, while the

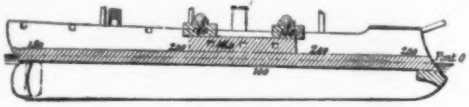


FIG. 5.—OCEAN.

Gloire and very many of the ships of our armored fleet have disappeared under the ax of the demolisher, because they were not built of iron. The Couronne will live for a long time to come. A metal ship, kept in good repair, has a duration that cannot be compared with that of wooden vessels.

In 1861, Dupuy de Lome drew the plans of the Flandre (Fig. 3), which differed little from the Gloire. The length was extended to 267 ft. and the displace-

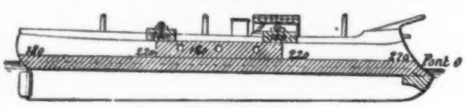


FIG. 6.—RICHELIEU.

ment to 5,816 tons, thus permitting of an increase in the thickness of the armor and the height of the battery. The armor was 6 inches thick at the load line and 4⅓ throughout the height of the top sides, thanks to certain savings in weight that had been made elsewhere.

The ten frigates of the Flandre type made from 13 to 14 knots. Only one of these remains upon the list, and that is the Heroine, the only one built of iron.

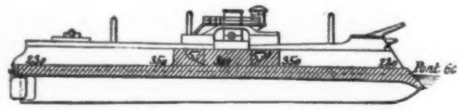


FIG. 7.—REDOUTABLE.

As it is not within the scope of this article to give a complete history of our armor-clad fleet, we shall cite, as a reminder only, the Magenta and Solferino (Fig. 4) with their two gun decks, and an armor of the same thickness as that of the Gloire.

As early as 1865, the progress of rifled artillery proved that armors of 5 in. were inadequate. The Ocean (Fig. 5), Marengo and Suffern group was then put on the stocks. These three vessels were characterized by the increase of the armor to 8 in. at the load line, in order to resist the 9 in. guns of the model of 1864. The principal feature of the ocean group is the arrangement of the artillery. On the ships that precede it, the firing in chasing or retreating is assured only by two unprotected decks. On the Ocean and its congeners, four armored turrets are employed, and these contain four 9 in. guns, two of them capable of firing on retreat

and two on giving chase, and covering nearly half the horizon.

It was the barbette turret making its first appearance. As for the armored redoubt, that is provided with four 11 in. guns fired from portholes. From 5,900 tons, the displacement of the Flandre type, the tonnage passes in the Ocean to 7,750 tons. The weight of the armor in the two types is respectively 946 and 1,380 tons, say for the first 16 per cent. of the displacement, and for the second, 18 per cent.

On the Richelieu (Fig. 6), Colbert, and Trident, the armor is 8⅝ in. thick. But these vessels closed the list of wooden armorclads. Several ships of the first period of armor plating were already nearly out of

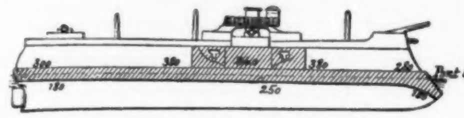


FIG. 8.—DEVASTATION.

service, and the continual renewing of so costly vessels would have been an enormous charge for the country. The thickness of the armor, moreover, was insufficient, and in order to increase it, it would have been necessary to increase the dimensions of the vessels designed to wear it, and this was impossible as long as the hulls were constructed of wood. Metallic construction, which was adopted in England for all armorclads, presented such advantages that it daily obtained partisans, despite the resistance of a few officers who did not know what to make of this overthrow of a material so long immutable and which they had been brought up in admiration of. Construction in iron, besides the guarantee of the double hull, permits of reducing the weight of the hulls to the great benefit of the armor and the armament, that is to say, to the profit of the offensive and defensive power.

Upon the Redoutable (Fig. 7), of 8,857 tons, the armor is 14 in. thick at the load line. It rises in the center to form an octagonal redoubt protected with 12

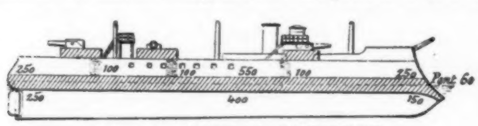


FIG. 9.—AMIRAL DUPERRE.

in. armor plate, containing four gun ports, and armed with four 11 in. guns of the model of 1875. The deck armor, which was here applied for the first time with us, is 2½ in. thick.

The Devastation (Fig. 8) and the Courbet are derived from the Redoutable. Their displacement was raised to 10,090 tons, in order to increase the armor and the artillery. The armor belt is 13 in. thick, and the thickness of the armor of the redoubt is 10 in. at the sides and 11 in. at the front and back.

The artillery consists of four 14-inch guns in the redoubt, two 10-inch guns in turrets, and two pieces of the same caliber, one amidships and the other aft. The armored deck is covered with 2¼ inch plates. The speed is 15·17 knots. In the Amiral Duperre (Fig. 9) the displacement reaches 11,085 tons, and the armor 22 inches in thickness in the center of the load water line. The principal armament consists of four 14-inch guns in four barbette turrets having an armor

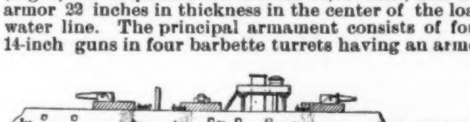


FIG. 10.—AMIRAL BAUDIN.

protection of 12 inches thickness. The deck armor is 2½ inches thick, and that of the funnel and the passages for powder and projectiles is four inches.

Following the order in which they were put in service, we now come to two armorclads, the Formidable and the Amiral Baudin (Fig. 10), which but a short time ago completed their first trials. They displace 11,380 tons. An armor 22 inches in thickness at the center of the vessel runs over the entire length of the load line. The armor plate of the turrets, three in number, is 12 inches in thickness, as is also that of the ammunition passages. The armor of the deck is 3¾ inches except over the engines and boilers, where it is 4 inches. The main artillery consists of three 14-inch guns. The speed with forced draught is 15 knots, although the Formidable has made 16·2. With the Hoche (Fig. 11), the Neptune, the Magenta, and the Marceau, we fall back to armor of less thickness than those of the preceding vessels. At the load line the plates are but 18 inches.

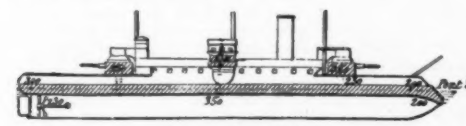


FIG. 11.—HOCHE.

We stop here. To be complete, it would be necessary first to pass in review our entire fleet of armorclad coast guards, in which the armoring has followed an increasing progression, as in the large armorclads. From 4¾ inches on the Arrogante, it passes to 6 on the Taureau, to 13 in the Tempete, to 20 on the Furieux (Fig. 12) and the Indomptable (Fig. 13). Next it would be necessary to linger over the armorclad cruisers and gunboats, whose plates are of relatively slight thickness. But it is sufficient to have indicated the progress made in protecting the large squadron armorclads to make its greater and greater importance understood.

Finally, to show the maritime treatment since the adoption of armor plating, we cannot do better than to copy textually the following paragraph from Engineer Hauser's treatise:

"If," says he, "we consider the route pursued since the first armorclads up to the Amiral Baudin, it will be seen that the transformations that have occurred may be summed up as follows:

"The total displacement is nearly doubled, having passed from 5,800 to 11,400 tons.

"The wooden hull is replaced by one of steel, and passes from 14 per cent. to 33 per cent. of the displacement.

"The armoring of 6 inches passes to 22 inches.

"The artillery, placed at first entirely at portholes, gradually passes into turrets, and the armored redoubt is entirely suppressed. The calibers increase from 9½ to 14 inches.

"At the same time, there is but slight increase in

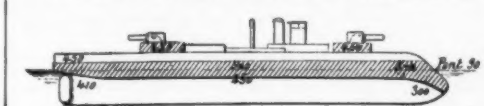


FIG. 12.—FURIEUX.

the number of the crew. It is 582 on the Flandre, 750 on the Marengo, 500 only on the Amiral Baudin."

As regards the armor especially, it is every day assuming greater proportions. Thus, it weighs 946 tons on the Flandre, 1,380 on the Marengo, 1,697 on the Richelieu, 2,502 on the Redoutable, 2,728 on the Devastation, 2,899 on the Amiral Duperre, 3,370 on the Marceau, and 3,942 on the Amiral Baudin.

However, it is to be remarked that such increases in the weight and thickness of the plates have coincided with a diminution in the surfaces protected. Limited to the load line, the turrets, and the main decks, the armor thus carried protected only the vital parts of the ships, leaving exposed to the ravages of projectiles large spaces that were of less importance to floatability, but the entrance of powerful explosives into the lists marks to-day a new step toward a total armoring. Applied in France to the cruiser Dupuy de Lome and the armorclad Brennus, and in England upon the 14,000 ton armorclads that are about building, it tends

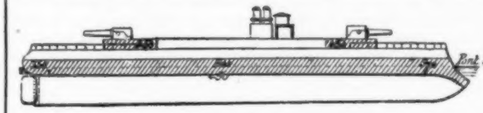


FIG. 13.—INDOMPTABLE.

to become general in all navies. The protection of the submerged part now appears to be insufficient; an endeavor is making to protect the artillerymen against the numerous burstings of the new shells, and it is by combinations based upon armor plating that it is hoped the object will be attained. Hence the increase in surface of the parts of the ship covered with armor, and that step toward a more extended armoring than that which we find in war ships belonging to what is called the "new fleet."

Alas! all the vessels that compose the latter are not yet in service; some have not yet even been launched, and they are already considered inadequate.

In less than 40 years, we have constructed two armorclad fleets, but the progress of the art of destruction has been so extraordinary that they no longer answer our requirements. To-day, we are outlining a third, being in advance, in this, of all maritime powers. But it is easy to foresee that we shall be rapidly surpassed, and that we shall have but the consolation, in our approaching infirmity, of showing that we were the precursors.

It is French science that invented the first armorclad ship, and it is to it that are due the first naval structures in steel and the large plates of the same metal, and it is it too that has rendered practical the use of powerful explosives and demonstrated the necessity of a more efficient protection. But the slowness of our system of construction and the hesitation of those who govern us permit us rarely to acquire the position that legitimately belongs to us, and that would be merely the just recompense for so much effort and intelligence expended for the improvement of our armament.

(*To be continued.*)

VENETIAN GLASS.*

By DR. GIULIO SALVIATI.

IN accepting the invitation of the committee of the Applied Art Section to read a paper on the manufacture of Venetian glass before this society, I fear I may have undertaken too great a responsibility. It is a subject which, from its ancient and historical treatment, may suffer at my hands. I can only say I will do my best, and should the subject be inadequately presented by me, I shall beg your indulgence for all shortcomings.

I need not mention here the tradition of the first discovery of glass; we have all read of the Phenician dealers in soda who, while taking refreshment on the banks of a river, noticed with great astonishment that the amalgamation (produced by the action of their fire) of soda with sand and the herb alkali had produced a transparent substance, which was afterward purified and otherwise improved till it was converted into glass. How far this tradition may be true this is not the place to discuss, for I must confine myself to that specialty which is known as Venetian glass.

You are doubtless aware that Venetian glass is not actually manufactured in Venice proper, but at Murano. Venice being the most important and best known city, has always lent her name to the art.

Murano is the prosaic name of an island built on the north of Venice, from which it is distant about half a mile. It is said that the name was derived from the Latin words, *murus muralis*, but I believe the name has a more local derivation. The island being washed by a northwest current of the Adriatic sea, which by its ebb and flow continually removes the otherwise stagnant water of the lagoon, I think that the true derivation of its name is from *maris amnis*, which means "river of the sea," and in the subsequent changes of the language became Murano.

* Read before the Society of Arts, London. From the *Journal*.

It is said that the reason Murano was chosen as the seat of the art of glass blowing was on account of its peculiar geological position, which has no rival in Europe, and is only partially equaled by Reichenau in Bohemia.

The bed of the sea which washes the shores of Murano is composed in great part of quartz or silica, materials which are brought thence from the Alps in torrents. These materials or sand form one of the principal ingredients needful for the manufacture of Venetian glass. I may mention that some time ago the Minister of Public Works, on the request of the Chamber of Commerce of Venice, prohibited the use of this sand for any other purpose, and also prohibited its exportation.

There must be something peculiar in the natural position of Murano, as is proved by the fact that when the demand for the glass increased almost beyond the capabilities of the restricted space at command, the Muranese did not think it advisable to extend their furnaces and works to the neighboring islands. Not only is this restriction attributable to the natural position of Murano, but also to the personal peculiarities, in some measure, of the artists themselves.

They commenced their works naturally with the simplest forms used in daily life; afterward, when they found a demand for something richer, more elaborate and complicated in design, they worked on step by step in their profession, discarding all use of moulds and contrivances for making easier and quicker their labors, intent only on perfecting their art works, and making every piece a real work of art, of which they are and always were extremely proud. So much do they identify themselves with their works, that there are certain forms and designs which are quite traditional. These have been handed down for generations from father to son, and are known by the family name of the artist producing them.

It would seem, from the variety and immense numbers of tints and shades, that a knowledge of chemistry would be needed in the formation of the base of this manufacture. Such, however, is not the case, as a reflection on the ignorance of this science 200 or 300 years ago will prove. This was about the time when Murano began to be renowned for her splendid productions, a renown which has been more or less maintained until the present day.

The artists had neither the time, nor the means, nor desire, to occupy themselves in chemical studies; but continual experiments and practice on certain traditional lines, together with patience and determination to succeed, are and have been the chief moving powers in their works.

Some time ago a celebrated professor of chemistry, while questioning an old artist as to the manner in which he learned to make such an enormous variety of tints, asked him by what means he had arrived at such knowledge. The old artist told him that the grammar which he studied, and which was the key to all his success, was practice, and that he would defy the professor, with all his scientific skill, to produce the same color as he had just then produced. He added that the Muranese artists were like the birds, who could sing without having learned music.

For certain compositions there are naturally secrets, which are kept with scrupulous care, and handed down from father to son either by example or by simple writings.

Owing to the extremely good feeling which has always existed between Murano and the city of Venice, the former was especially favored, and received many honors from the "Queen of the Adriatic." In the year 1223 the doge and senators gave instructions that the names of the principal *maestri*, or heads of the glass blowers, should be entered in the public records as being the names of persons to be held in high esteem and respected in the history of the republic. The senators and the council of ten established laws for the protection of the glass manufacture.

At the period of the renaissance the works at Murano had reached such a point of perfection as to eclipse, by the originality and beauty of their productions, all the works in glass made by the Egyptians, Etruscans, and Romans.

The artists of this age were invited to and received at all the courts of Europe, and their works were universally proclaimed as exhibiting the inspiration of genius, and as doing the greatest honor to the industrial arts.

The Venetian government at this time was well aware of the immense moral and financial advantage which this manufacture brought to the country, and consequently took every precaution to prevent the secret of the manufacture from being learned by foreigners, and the Murano workmen were absolutely forbidden to carry their skill beyond the boundaries of the island of Murano. Artists who were by any means seduced from their allegiance, and persuaded to accept employment in other parts of Europe, were visited with severe punishment, and in some cases by actual death, while the state rewarded those who, by special skill or otherwise, distinguished themselves, and who remained faithful to their country, the senate even granting them the privilege of electing a chancellor to administer justice at Murano. The Venetian nobility also did not think it derogatory to their position to marry their children with the children of the Muranese *maestri*, and the children born of these marriages retain all the privileges of the nobility.

But even to Murano this age of glory and prosperity was not to be perpetual. By and by the "Queen of the Adriatic" declined, and the sunset of her political and industrial day caused the decadence also of her cherished and beloved neighbor, the island of Murano. In the 17th century the artistic perception of form and color was lost, and it was distressing to compare the heavy, shapeless, highly colored objects then made with the exquisite colors and graceful designs of past years. The darkness of night had succeeded to the light of sunny days, which appeared to be gone forever.

The republic made several efforts to arrest this decay, by loading the artists with gifts and by granting them many privileges, also by imposing heavy taxes on the importation of foreign glass. Still the French and Bohemian glass had taken a strong position, and the continual purchase by Venetians of these wares contributed to the dying out of what until then remained of the production of art in Murano.

In the year 1700, when the art of glass blowing was

at its lowest ebb, Giuseppe Briasi made efforts to give new life to it, and being possessed of an indomitable will and great perseverance, he endeavored to restore the ancient beauty of form and color, by producing some fine specimens of chandeliers, and candelabra, and vases, in which could be seen some remnant of the past glory, but the prevailing taste of the period only served to injure instead of improving his efforts. His efforts were followed by others, viz., Bigaglia, Seguso, Barbini, and Mialti; but all suffered the same fate, and their labors were rendered futile by the prevailing taste of the time, and their labors resembled the last dying flicker of a candle previous to its entire extinction.

At last the republic died, and the art of glass blowing at Murano, which had hitherto been guarded and protected by Venice, fell into lethargy, but it was not really dead nor even entirely forgotten. The elements of its existence and prosperity were not entirely dependent on political changes; and its traditions were bound up in the souls of the old artists of Murano, descending to their sons and grandsons, and it only required a fresh impulse to dispel the torpor and gloom in which it was sunk.

It was the pleasant duty of my father, Dr. Salviati, to give this first impulse and to raise the dormant genius, and give new life and energy to this lovely and brilliant art, with what success we all know. My father was a lawyer of good repute, and while exercising his professional duties at the Venetian forum, he spent his leisure hours in admiring and studying the sublime works left by his ancient compatriots. It grieved him that such lovely works should be doomed to oblivion, and in the year 1856 he conceived the arduous idea of reviving the mosaic art, and resuscitating it from the tomb of the past. He read and studied all books relating to the manufacture of gold and colored enamel, and having associated himself with Lorenzo Radi, of Murano (an artisan who for many years had occupied himself in studying the manufacture of the first material necessary for mosaic), he relinquished his profession of the law and dedicated all his energies and fortune to the development and perfection of the gold and silver and colored enamels for the manufacture of Venetian mosaic.

Their first joint attempts were so successful as to deserve the highest encomiums from the Royal Academy of Fine Arts in Venice. A committee, consisting of painters, sculptors, and architects, was chosen from members of the academy, to carefully inspect, examine, and report upon the enamel produced by my father. After carefully examining, they declared that "the gold, silver, and colored enamels produced by Dr. Salviati are even superior to the enamels of ancient times." It is not within the scope of this paper to give a history of the revival of mosaic by Dr. Salviati, nor a *resume* of the various failures and successes by which the result was obtained, only to say that this discovery of the means of making the enamels was the first step in the revival of the art of glass blowing at Murano, as it was while so occupied that Dr. Salviati was persuaded to attempt also the restoration to Venice of this lost art. He was much helped and encouraged in the enterprise by Mr. Norman Shaw, one of the chief ornaments of his profession as an architect, who was quick to perceive that my father possessed the needful element of perseverance for this revival. He was also ably helped and advised by the late Mr. E. W. Cooke, R.A., the late Sir Gilbert Scott, also by Messrs. Clayton and Bell, and others, who saw in the revival of mosaic a hope that the glass industry might also live again.

My father never ceased to express how grateful he always felt to these gentlemen for their artistic advice and help to him, and for their valuable counsels and encouragements, which helped him to persevere and conquer the apparently insuperable difficulties in his path.

The composition of the first material needful for the manufacture of mosaic has many of the qualities necessary for the production of the Venetian glass composition. Hence it was an almost certain conclusion for a man with the energy and determination of Dr. Salviati not to rest satisfied when the difficulties of mosaic were conquered until those of the glass were also surmounted. It was no easy task to train the glass blowers, and to make them forget the clumsy and heavy productions to which their hands had become accustomed, and to resume the light and elegant forms of the past times when Venice showed so great a pride in her artists, especially when we consider such lessons had to be given and received before a burning furnace, and then, even when success crowned their efforts, there were many disappointments. I need not enumerate the numerous difficulties which had to be met and overcome before Dr. Salviati was in the proud position of being able to say, "Now again is Venice famous for her blown glass and mosaics."

The glass blower of Murano is no mere mechanic or artisan, he is in every respect a true artist, an artist endowed with the perception of beauty and genius, who invents and creates daily new forms and colors. The glass is to him what the chisel is to the sculptor, the brush to the painter, and the works he produces are the offspring of his talent, and the perfection of form, delicacy of color, and lightness are his hobby, and when, after several arduous trials, he succeeds in producing a splendid specimen of his art, all the fatigue is forgotten in the legitimate pride and pleasure with which he looks upon it and says, "This is mine."

Under the name of "Venetian glass" is comprised not only the elegant vases and goblets and ornamental objects, but also chandeliers, candelabra, mirrors, table glass, and roundels of sheet glass for windows, etc., for which Venice was famous.

There are a number of names used to express the various kinds of glass, thus: The "ritorto," a kind of stripe of different colors on a plain ground; the "fiamma," a mixture of many different colors, so named from its appearance of flames; the "retticello," which represents delicate lace patterns; the "aventurine," looking like brilliant gold; the "festoncino," having the appearance of threads; the "chalcedony," looking, as its name signifies, like some stone or marble, etc. These various compositions all require different treatment, many needing several days in preparation.

The tools used by the artists are few, and very simple, a hollow, long tube of iron for blowing, a large pair of shears for cutting (similar to those used by tailors), a few other instruments for measuring, and a stamp with a strawberry-shaped die—these compose all the instruments used in the production of all the articles, even in a *tour de force*, which is the term used to express the most complicated designs. The production of a vase or other article is obtained in this way: The end of a blowing rod is dipped into a pot containing molten glass, and a portion of it accumulated on the end. It is essential that the quantity which adheres to the rod should be accurately guessed for the size of the vase or other object which it is intended to produce, be it a small wineglass or a large tazza. If the quantity taken up is too small, the article produced will not be of sufficient size, and naturally if too much is taken the article produced will exceed the required dimensions. This lump of liquid glass is then rolled on a table by giving a few turns of the blowing rod; it is then blown by the artist slightly, then reheated in the furnace. This process is repeated each time the article takes a more definite shape, until after repeated heating and blowing, the lump of glass is blown into a vase, cup, or other article. During the whole operation the artist remains in front of the furnace, as the material must be kept in a liquid condition until the right form and size are obtained. Having thus made the body of the object, the artist now proceeds to form the foot or stand. In this he is assisted by another artist of inferior grade who has prepared meanwhile a piece of the necessary material on a blowpipe, and who has blown it hollow. This he keeps in a liquid state, and in order to prevent it from dropping off his pipe he has to continually turn it round and round. The right moment must be watched, and then the two parts are joined; a twist, a pull, and a little dexterous manipulation, and the stem is formed. The article is again placed in the furnace; meanwhile the maestro, or chief artist, takes up a small portion of another colored material, then, taking the article from the furnace, he proceeds to ornament it with strawberries, flowers, leaves, or other devices; between each operation the article is introduced to the furnace to keep it soft; of course it has to be carefully held in shape. It is astounding to see the numerous variety of decorations which the artists produce for the embellishment of the objects. There are serpents, dragons, flowers, leaves, handles, etc., nothing is too complicated or simple, one and all are modeled by these instruments. Some vases require the attention of four artists at the same time, and require from one to two hours of uninterrupted labor. During this time they are placed in and out of the furnace thirty or forty times. While they are in the furnace they have to be kept in position by a special artisan called a "forcellante," whose duty it is to keep the article turned round and round, and who must watch that it does not drop or in any way lose its form; for this purpose he uses a long fork-like instrument. This he has to do standing in front of the mouth of the furnace until the article is sufficiently cool to retain its shape without assistance; then by slow degrees it is introduced further and further into the cooler part of the furnace where it remains cooling until the following morning. The painter and sculptor know how difficult their art is, and how much practice they must go through before they can draw a model accurately. How much more difficult, then, must it be for an artist to have to mould his subjects from the pliant and semi-liquid glass, and to be obliged to work at such a speed as to prevent the glass from cooling too much for manipulation.

This general process of blowing is applicable to self colors, such as opal, ruby, aqua marina, etc.; but when the object to be produced is to be made of the richer and more complicated wares, such as the retticello, ritorto, filigree, etc., then the material requires a separation, which process (according to the material required) takes from one to three days. These are prepared in long strips called "canna," and when covered with crystal and ready are placed side by side on a kind of shovel, which is put into the furnace; as they melt they adhere to each other, and the workman with a piece of half-melted glass on the end of his rod presses on the ends, then with a dexterous twist he winds them all up into the form of a cylinder, the end of which is fixed to the handle that is to control them during subsequent operations.

When thus ready, the artist dips the end of his blowpipe charged with the cylinder of prepared strips or canna into a pot of ordinary clear glass, which is to protect the delicate lacework or the sensitive aventurina. He then proceeds to roll them on the marver or little iron table, and when by heating, rolling, and blowing they form a compact body, he proceeds to cut off a piece of the required size, taking care that the strips are all evenly joined. The vitreous mass thus obtained is then treated by the artist in the manner I have already described to you, and he proceeds to fashion his jug, vase, glass, tazza, or other object. The pattern which was thus imprisoned in the small strips is now by blowing fully developed.

If no twisted movement has been given during the operation, the lines of lacework or other work remain straight; if, on the other hand, a different movement has been given during the process, the lines will have a twisted effect, as is often seen in Venetian glass. The filigree is prepared by minute thread-like strips inclosed between two sheets of crystal glass; the threads are sometimes crossed, and then minute air bubbles are imprisoned between the two sheets of glass, having a beautiful effect when completed.

The "fiamma" is prepared thus: Upon a hollowed and rolled lump of material are laid strips of aventurina and other colors which are to form the "flames," which are wound spirally round; they are then heated, and while in the oven, and before the fusion has proceeded very far, a sharp-edged piece of iron is drawn across them several times, so that there are ridges both ways on the mass, which gradually amalgamates into one piece. On coming out of the fire, the object is subjected to extra twisting beyond that necessary to give it its proper form.

The "millefiore" is a lengthy process. First there are strips made of a certain pattern according to the taste of the artist; these strips are incased in clear glass cut up into lozenge-shaped pieces, then laid on a surface of any colored glass desired to form the ground work of the contemplated article; the whole is then heated and blown, developing, as it proceeds, the pattern contained in the small lozenges on a clear or colored ground, producing a lovely effect. By this process all kinds of designs can be produced, animals, insects, and even portraits, distributed all over the vase, jug, or other form. A portrait is formed by the artist taking several strips or canna of the requisite tints, and putting them together in a similar way by which a mosaic portrait is made; this is, as may be imagined, a very delicate and difficult operation. When thus arranged they are covered with a thin coat of crystal, which serves the double purpose of keeping them in place and of preserving them; the mass thus prepared is then inserted into the furnace, and when it commences to melt, two artists, each having an iron tube with a piece of molten crystal on the end, take hold of the mass, one at each side. They move very quietly in opposite directions, which has the effect of elongating the round strip, which is stretched longer and longer until it presents a long thin round strip, which has been kept firmly in place by the coating of clear glass, and which preserves perfectly the portrait all through. This strip of prepared canna is then cut into very thin lozenges and used the same way as in the previous preparation, being used to ornament plates, jugs, goblets, etc.

The aventurina is a metal preparation produced by the fusion of various component parts; this is a material used to give the exquisite brilliancy and luster so much admired in Venetian glass; it is a very difficult and tedious process, and exceedingly uncertain in its results. This process is one of the chief secrets of Venetian glass, and is only known to one or two of the maestri. It is said the name "aventurina" is derived from adventure, on account of its always uncertain results. The use of a little more or less heat than is absolutely necessary, or some other cause (mostly inexplicable to the most experienced artist himself), will cause the whole mass to be a failure, after three or four days' labor. Instead of being the brilliant aventurina the artist expected, he finds on opening the oven a mass of a composition of a dull brick-like color.

The aventurina is used not only in the glass blowing, but also in the jewelry when it is cut and polished. When used in glass blowing, a great amount of care must be exercised, and it must be protected by a covering of crystal, otherwise all the sparkling effect would be lost.

The fires used in blowing Venetian glass are made of wood, coal being useless on account of its generating too much smoke and gas, which prevent the delicate ornaments used in decorating the various objects from adhering. Ornaments and vases made by *coal* or *gas* alone would soon separate into their various parts.

The artists are from their entrance allowed a certain time daily for study, during which they design and create new shapes and colors. In this of course some are more skillful than others. They work together in the greatest possible harmony, each one aiding the other to develop and perfect any new idea, and the interest with which they all anxiously await the moment when a new-shaped vase or a new combination of color is to be withdrawn from the oven is surprising. There seems no personal jealously, every one is equally as interested, from the youngest boy to the oldest man. They perfectly understand the capabilities of each one among them, and when the vase, or tazza, or other object is to be made, each artist immediately prepares for his individual part; thus should the object required be of unusual dimensions, it is at once undertaken by those men who have the strongest lungs for blowing; again, should it be an exceptionally fragile and delicate vase, it is undertaken by the artists known to have the lightest hands; the most difficult forms, such as griffins, dolphins, birds, etc., being the special work of certain artists only. I do not think it is easy to find such harmony as exists between artists employed at Murano. I can say that I never heard an angry word among them, and all mutually help one another; they are more happy when at work than when having holidays. These they are obliged to take during the end of July or August, when the furnaces are allowed to go out. The temperature being excessive, it is found impossible during this period for the men to work, so this opportunity is taken advantage of to build new furnaces.

There is one dreadful circumstance which they must all face, and this is blindness. It is unhappily the fact that nearly always, after many years of work, and when they are between forty and fifty years of age, they begin to lose their sight, and after a little while they can see no longer. There is no means of preventing this; it is caused not only by the excessive heat, but also by the glare of the continual flames. Many things have been tried, and several kinds of protection for the eyes, but without avail.

Fortunately, when the dreadful event occurs, they have not the additional suffering of want to face, for while at work their wages are very high, often surpassing those of their magistrate, and their mode of life simple. They thus save large sums, and their declining years, if passed in darkness, are at any rate of ease and comfort in other respects.

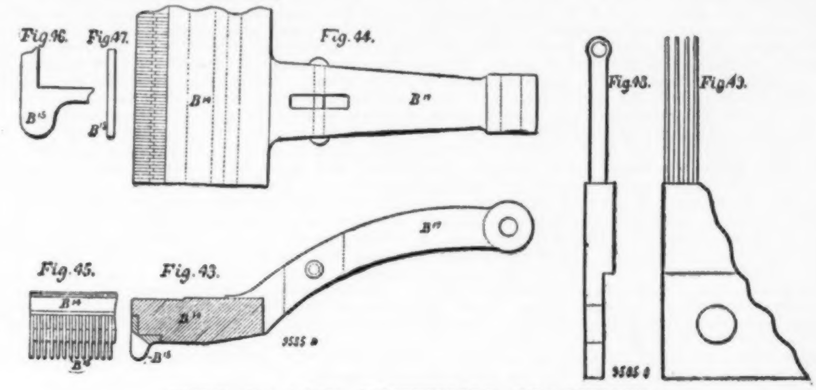
I will now conclude my paper by simply stating that it is now over 25 years since this beautiful art of Venetian glass blowing was revived by my father, and that it has continually progressed in form and colors, the demand for it always increasing, not only in this country, but in France, Germany, America, and indeed all parts of the globe where people are cultivated and appreciate works of art. Its cost, as you can understand, now that I have told you how each piece is made, is naturally greater than that of those glass articles which are moulded, but then its beauty is equivalent to its value.

DISCUSSION.

The chairman said the aventurino, which was frequently mentioned in the paper, was the gold glass in which the gold was produced by means of copper, and when the glass was heated too much, the brilliancy of color was lost. He had seen vases made in which the lace-like work was introduced in the following manner: The workmen took a number of canes and put them into a pot with a little sand to keep them in place, and then dropped a piece of hot glass kept till it had sufficiently warmed the different canes, when they adhered, after which they were pinched with the pinchers, and then covered with a little film of glass. They were then taken, while heated, and twisted and drawn out until fine lines were obtained. There was a great deal of truth in the statement that the artists at Murano did not know much of chemical science, but still there were certain broad rules of chemistry which had been in possession of mankind in connection with the manufacture of glass from a very early date. It was impossible to trace the story as to the first discovery of

glass by the Phenicians, and he had no doubt that the Egyptians were acquainted with the secret of glass making some 4,000 years ago, as some very old specimens had been discovered in Egypt. The ancient Egyptians had a great reputation for producing sham jewels of a brilliant color, and glass on a large scale. Alexander the Great was said to have been buried in a glass coffin, and there were stories of pyramids of glass 50 feet in height having been made. No doubt these pieces were cast in much the same manner that plate glass now is. He thought there must have been a sufficient knowledge of chemistry in early days to inform people that by taking the oxides of such metals as copper, iron, tin, etc., different colors could be produced. In the Chinese collection at the South Kensington Museum there were some very remarkable specimens of colored glass, in fact they were so beautiful that they might almost be mistaken for precious stones. These were of recent make. There were also some very interesting Persian specimens, which more nearly resembled Venetian glass than the Chinese. The difference in treatment, and the time the glass had to be exposed in the furnace, to produce different hues, were no doubt secrets which were jealously guarded by the trade.

Mr. H. J. Powell, referring to the statement in the paper respecting the number of Venetian glass blowers who became blind, said he did not remember a single instance in which the blindness of an English glass blower could be said to be due to his occupation. He attributed the blindness of Venetian glass blowers to the fact that in Venice the men worked the glass in the flame of the furnace, whereas English glass blowers worked by the heat of a covered crucible, and were thus shaded. Practically, the same material was now being worked at Whitefriars as was used in Venice, and there was no difficulty in working it in a covered crucible, so that he could not see why this process should not be adopted in Venice.



THE PAGET KNITTING MACHINE.

[Continued from SUPPLEMENT, No. 712, page 11375.]

ON WARP WEAVING AND KNITTING, WITHOUT WEFT.*

By Mr. ARTHUR PAGET, of Loughborough, Vice-President.

WE will now follow the movements of the hooks, C, and explain how these are affected. The row of hooks is held by the hook plates, C1, in the hook bar, C2, Figs. 15 and 36, in the same way as the needles are held in their bar. The hook bar, C2, has attached to its lower edge two arms, C3, which are jointed by pins, C4, to the two arms, C5, of the rocking shaft, C6; at the other end of these two arms, C5, there is a bowl or truck, C7, which is moved away from the main shaft, F, by a cam, C8. The springs, C9, which are attached at their upper ends to the hook bar, C2, and at their lower ends to the bar, C10, pull the hook bar end row of hooks downward, and so keep the two bowls, C7, pressed against the two cams, C8, and always pulled toward the center of the main shaft, F. The lengths of the downward movements of the row of hooks, C, are controlled by the two double-hook controlling hooks, C11, which take hold of or stop the four projections, C12, attached to the arms, C5. The positions of these two double-hook controlling hooks, C11, are controlled by the actions of the two wedges, C13, attached to the bar, C14, which slides longitudinally in slides or bearings attached to the machine, similarly to that described in connection with the movements of the needles, B. Thus it will be seen that, by sliding the bar, C14, with its wedges, C13, to and fro longitudinally, the distances of the downward movements of the hooks, C, are easily controlled. The upper ends of the hooks, C, rest upon and slide in the grooves in the front of the knocking-over bar, D.

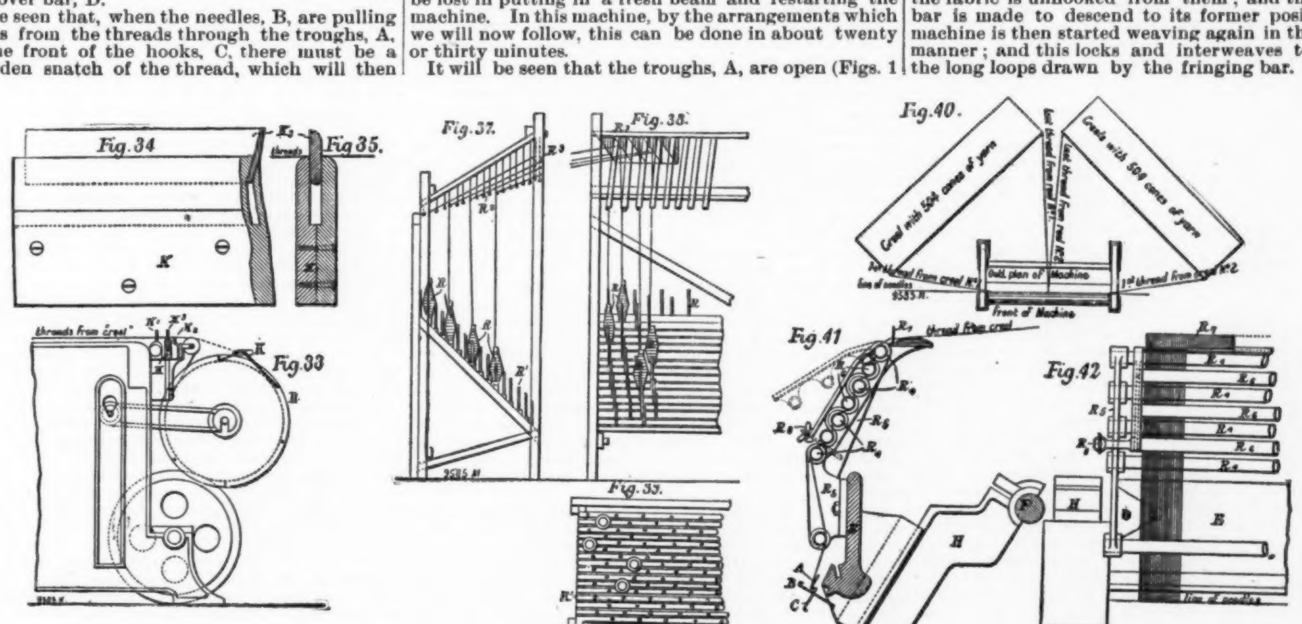
It will be seen that, when the needles, B, are pulling their loops from the threads through the troughs, A, against the front of the hooks, C, there must be a rather sudden snatch of the thread, which will then rest until the needles have advanced and again retired to this same spot, and are again pulling another row of hoops; this, of course, again produces a sudden snatch upon the thread, and thereby causes a sudden small rotary motion of the beam on which the threads are wound. In order to prevent this motion from being continued too far by the momentum of the beam, a certain amount of tension, drag, or friction is requisite upon the beam; and in consequence of these sudden jerks of the threads, the beam has to be suddenly started into rapid motion, and then stopped suddenly and started again. In delicate yarns this, of course, is liable to break the threads, and thus cause the speed of machine to be limited to a slow rate. To obviate this difficulty there is interposed near to the thread troughs, A, an arrangement called a reservoir bar, which will be understood by reference to Fig. 15. The rod, A24, is mounted in the machine so that it can revolve upon its center; and some arms, A25, attached to the rod, A24, carry another small rod, A26, which revolves with the rod, A24. After leaving the trough the thread is passed up and over the rod, A26, and then down and under the rod, A24, and thence up to the beam, A27. At the end of the rod, A24, is an arm, A28, which is pulled by a spring, A29, in the direction of the arrow, A30. This keeps the rod, A26, pressed against the threads; but when the snatch or sudden pull on the threads by the needles comes, this rod, A26, gives way, and allows the threads to be drawn from it without producing any great snatch upon the threads; and then, while the needles are performing the rest of their motions, the reservoir bars, A24 and A26, are being moved toward their former position by the pull of the spring, A29, and are thus drawing thread off the beam ready for the next row of loops. By this means the beam is kept steadily in motion at almost a constant rate, which, of course, enables the machine to be driven at much higher speed than could otherwise be attained.

In the ordinary warp knitting or weaving machines at present existing the ordinary warp guide is used, as is shown in Figs. 48 and 49. In the ordinary warp machine, when all the yarn on a beam is worked up and the machine requires a fresh beam, the ends are cut, and the old empty beam is taken down, and a fresh full beam is put up. If there are (as in this machine) 1,008 ends, the end of each thread in the machine has to be tied to each thread of the new full beam, or each of the 1,008 threads has to be threaded through its warp guide; this, of course, necessitates the tying of 1,008 knots, or the threading of 1,008 ends, and ordinarily in an old-fashioned warp machine this operation takes about three hours; but as the speed of the old warp machines is very slow, the operation requires to be performed only about once in two or three or more days. As the speed of the new machine, however, is so much greater, namely, 120 courses per minute, instead of only about from 30 to 50 courses per minute, a beam is often emptied in from one to two days; and it is evidently very important that as little time as possible should be lost in putting in a fresh beam and restarting the machine. In this machine, by the arrangements which we will now follow, this can be done in about twenty or thirty minutes.

It will be seen that the troughs, A, are open (Figs. 1 to 4), so that a thread can be passed into each trough without threading the end of the thread through the trough; and the open mouths of the troughs are at a distinct and definite distance apart from one another. When in the warping machine the beam is full, the ends, after having passed through the reed, K1 (which will be seen in Fig. 33), toward the beam, pass over and rest on another V-shaped reed, K2, and then there is placed under the threads a trapping bar, K. All the threads in the warping machine (in this case 504, being half the width of the warp weaver) are lying over the trapping bar, K, and all at exactly the same distance apart from one another as are the mouths of the troughs. The wedge bar, K3, is then placed over the threads and over the opening in the upper part of the trapping bar, K. The wedge bar, K3, is then passed downward into the openings in the trapping bar as shown in Fig. 35; and this wedge bar now takes hold of or traps every one of the 504 threads, and at exactly the same distance apart as the mouths of the troughs. All the threads of the warp are then cut off on the creel side of the trapping bar; and the trapping bar with all the threads attached to it is now fastened to the cheeks or ends of the beam. When the beam is put up in the machine, the trapping bar is again loosed from the beam, and is brought down toward the mouths of the troughs, and placed into position with regard to the troughs, as shown in dotted lines in Fig. 36. It will thus be seen that, if the trapping bar is placed so that each thread is opposite to the mouth of a trough, and if the trapping bar is then pressed against the mouths of the troughs and made to descend and slide down to below the troughs, as shown in Fig. 36, all the 504 threads will have been threaded through their troughs. The same operation is then repeated for the other half of the machine; and thus the 1,008 threads are threaded and the machine is ready to be started again, in from twenty to thirty minutes. This is done by a girl who attends to the machine, with a younger girl to assist her during the time of threading up, instead of requiring three persons for three to four hours.

In some goods, such as towels, bath sheets, antimacassars, and others too numerous to mention, it is very advantageous to be able to make in the machine a fringe at both ends of each article woven, such as a towel. The arrangement for doing this is shown in Fig. 15. On the front of the machine below the hook bar is a fringing bar, L, in which are held a row of hooks, L1. When the machine is at work weaving, these hooks lie out of the way behind the fabric woven; but when a fringe is required to be made, the machine is stopped, and the fringing bar, L, and the hooks, L1, are lifted up, and so the hooks pass upward behind the fabric; and if the fabric is pressed against the hooks and the hooks are slightly lowered, they then lay hold of the fabric and pull it downward, and so draw a long loop through every trough and round every needle; the length of these loops is arranged to be double the length of the fringe required. The fringing bar, L, and the hooks, L1, are then slightly lifted again, and the fabric is unhooked from them; and the fringing bar is made to descend to its former position. The machine is then started weaving again in the ordinary manner; and this locks and interweaves together all the long loops drawn by the fringing bar. After the fabric is all woven, the long loops are cut across the middle of their length, thus producing a thoroughly satisfactory fringe at each end of each towel or other article. It would unduly lengthen this paper were a detailed description to be given of all the arrangements by which these motions of the fringing bar are effected; and these arrangements are much more simple to understand by seeing the machine than to describe in a paper.

Of course, in an ordinary loom (with a warp and a weft), say 84 in. wide, if it were desired to alter the



THE PAGET KNITTING MACHINE.

* Paper read before the Institution of Mechanical Engineers at Paris.—*Engineering.*

loom to weave say four widths of fabric with two selvedges to each width, there would be much expense in altering the loom, and a great loss of space in three parts of the loom to allow for the three shuttles to lie in the space between the four widths of fabric; but in this machine a selvedge can be produced in a few minutes in any part of the 84 in. width of the machine, without any expense, and with the sacrifice of only the space occupied by one needle, that is, in this machine, $\frac{1}{12}$ inch.

In warp fabrics of the class now dealt with, each selvedge thread has the full length of loop pulled from it by the needle during only every alternate row of loops; and thus less thread is used in forming the selvedge than is required for the other threads of the fabric. Therefore, to produce a selvedge on any part of the width of the machine, it is only necessary to take three threads from the beam, and to lead them to the back of the machine, as is shown in Fig. 15, where each set of three threads at each pair of selvedges of the fabric is led to and wound upon a bobbin marked M. This bobbin is held by its axle in the forked guide, M1, so that the bobbin, M, rests upon the narrow wheel or drum, M2, fixed to the shaft, M3, which is held in bearings at each end in the framing of the machine, and is driven from the main shaft at a suitable speed. As each set of three threads is led to the bobbin, M, it is passed through a guide, M4, which has a traverse given to it so as to lay the thread equally upon the barrel of the bobbin, M. To produce a pair of selvedges, two bobbins, M5, are hung upon a rod, M6, in the front of the machine, and upon each of these bobbins hangs a kind of flat hook or bonnet, M7, which produces a regular and equal drag upon the thread as it is unwound from the bobbin. These two threads are led to the two outer of the three troughs from which the threads were led to the back of the machine from the beam, and are threaded through these troughs and led to the needles which are to be the selvedge needles; if the machine is then made to weave in the ordinary manner, it will be seen that a selvedge will be thus produced at any part of the machine, with the loss of only $\frac{1}{12}$ in. to each pair of selvedges.

We will now follow the movements by which this machine produces shaped or fashioned fabrics, such as the bodies of vests for ladies, such bodies being shaped properly so as to fit the figure.

This shaping of the fabric is produced as before mentioned, by suitably moving the wedge bars, B13 and C14, Figs. 23 and 24, and thus varying the lengths of the needle and hook pulls and the widths of the fabric. These two bars, B13 and C14, are connected to a lever, P, by the rods, P1 and P2. The lever, P, works upon the fixed center or pivot, P3. Thus it will be seen that, by moving the lever, P, on its center, P3, both the bars, B13 and C14, are moved, and consequently the double needle-controlling hooks, B10, and the double hook-controlling hooks, C11, are also moved; and thus the lengths of the loops pulled by the needles and held by the hooks can be varied and controlled simultaneously by moving the lever, P, while the machine is running full speed.

The main features of the mechanism which automatically controls these movements of the lever, P, and the bars, B13 and C14, are as follows. A chain is caused to move in the direction of its length (on a suitable guide), through one link for each revolution of the main shaft of the machine; and for this purpose the chain invented by the French engineer Vaucanson, and well known as "chaine Vaucanson," has many properties which render it peculiarly suitable. Upon this chain are arranged two rows of inclines or wedge-shaped projections, at any desired intervals apart; each row of inclines sets in motion an arrangement of levers and ratchets with a worm, gearing into a rack on the wedge bar, B13. One row of inclines causes the wedge bar, B13, to move in one direction and the other row causes it to move in the opposite direction. Thus, as the chain advances, an incline of one or other row comes into action, and then the wedge bars are moved in one or other direction, and consequently the length of the loops pulled is increased or decreased as is required; and thus the width and shape of the fabric is governed by the number and position of the inclines upon the chain.

The description of the many small and complicated details of this automatic mechanism for shaping the fabrics is not here attempted. Shaped fabrics are made automatically by this mechanism at the rate of 120 courses per minute, either upon the whole width of the machine or with the whole width divided up into any desired number of divisions. Thus from three to five bodies for shaped ladies' vests, or from six to ten sleeves, can be made simultaneously, all full shaped, at the rate of 120 courses per minute without stopping, except for about three or four minutes to make a fringe or finish at the commencement of each set.

In some cases the machine is arranged for drawing the threads to be woven direct from the ends of the cops or cones as received from the spinners, without the threads being either rewound, or warped, or beamed. In such cases the cops or cones of thread are placed upon a special stand or creel. Fig. 37 is an end view of the creel, Fig. 38 is a front view of part of it, and Fig. 39 is a part plan with the top removed. The cones of thread, R (of which only four are shown in each view to avoid confusion), are placed upon suitable pegs, R1, which are set in rows one above another. Rows of top guides, R2, are arranged so that one guide is over each cone of thread, and a corresponding number of guides, R3, are also placed along the front of the creel; each thread is passed from its cone through the top guide immediately above it, then through a front guide, and then to the machine. Two of these creels are placed behind the machine. Fig. 40 shows an arrangement of two creels, where the directions of the first and last threads only, from each creel, are shown by lines. Figs. 41 and 42 show how the threads are guided at the machine, and how the necessary tension is produced; Fig. 41 is a part section and Fig. 42 a part front view of the arrangement. Four fixed rods, R4, reaching from end to end of the machine, are carried by brackets, R5. Three movable rods, R6, are fixed to side frames, R7, which hook on to, and are free to turn upon, the top fixed rod, R4, in such a manner that the movable rods, R6, can be placed between the fixed rods, R4, as shown; or they can be turned into a position such as shown in dotted lines in Fig. 41. The threads coming from the creel are passed through the reed, R7, and above the fixed rods, R4, down to the thread troughs, A. The movable rods, R6, are then placed in position shown, and are held there by a screw, R8. Thus it will be seen that the threads pass alternately over a fixed rod, R4, and then under a movable rod, R6; and by adjusting the screws, R8, the position of the movable rods, R6, between the fixed rods, R4, is regulated, and the tension on the threads can be increased or decreased to the required amount.

The last point of peculiar construction which will now be noticed is the method of making the grooved part of the presser, B14, where the walls of the grooves of the presser press upon the beards of the needles, B. The presser, B14, must have recesses or grooves formed in it, so that the hooks, C, can pass into these grooves when they rise above the fabric; and thus there is only a small wall of metal at the side of each hook and over each needle, which wall has to stand all the work and wear of pressing the needle beards and guiding the tops of the hooks, C. These walls should, therefore, be of hard and tough metal—in fact, should be of tempered steel; and if they were formed by cutting or grooving them out of solid steel, the expense would be very great. To avoid this, each wall, B15, is made separate, and punched out of steel plate of the shape shown in Figs. 46 and 47. Longitudinal recesses are planed in the bar, B14, as shown in Fig. 43, for the walls, B15, to fit into; and they are placed in these recesses and there held at the right pitch (or distance apart) by a comb bar or chuck, and while so held are soldered to the presser, B14, as shown in Figs. 43 to 45. Besides attaching each wall firmly to the bar, the solder fills up the spaces between the walls, B15, except where the hooks, C, have to pass between them as shown. A sample of such a presser is upon the table.

There are many other points of peculiar construction and detail about this machine which might be interesting, but the description of which would take too much time. The machine itself can be seen at work in the exhibition, and all details will be explained to those interested.

CABLE TELEGRAPHY.*

By PATRICK BERNARD DELANY.

BEFORE entering upon a description of the method of operating cables, I will make brief allusion to the general subject for the benefit of those who have not had occasion to know much about such matters.

It is claimed by our friends over the water that the first cable worth mentioning was laid in 1850, between Dover and Calais, but it is well known that a cable, insulated with gutta percha, was put down across the Hudson River at New York in 1848. The 1850 cable across the Channel worked but a few hours. Another was laid a year later, and operated successfully. England and Belgium and Ireland and Scotland were soon after connected.

Up to 1857, when Cyrus W. Field projected the Atlantic cable, the longest cable laid was about 600 miles, I think, in the Red Sea. The first attempt to stretch across the Atlantic was abandoned after 350 miles had been paid out from the Irish coast, the cable having parted. In August, 1858, a cable was successfully laid to Newfoundland. It worked but a few days, however. Some contend that the powerful batteries used in its operation burned the conducting wire. There is no doubt about the battery having been too strong, but even so great a man as DeSauty had to learn by experience, costly as it was.

In 1865, another attempt was made, with improved cable, strong enough to sustain eleven miles of its own weight in water. The Great Eastern took 2,300 miles of it, in three large tanks, on board. After numerous mishaps, this cable broke when the big ship was 1,000 miles on her way over, and in water nearly three miles deep. During the following year, however, a new cable was laid from Valentia Bay, Ireland, to Heart's Content, Newfoundland, 1,670 nautical miles, and the abandoned cable of the year previous was picked up, spliced, and completed. There are now ten cables across the Atlantic, and their location and condition is about as well known to those who have to do with them as though they were exposed to view for the entire distance. It has been said of Captain Trott, the well known cable fisherman, that he knows the mountains and valleys, lanes and avenues of the ocean as well as a cabman knows the streets of London. Crossing the Atlantic on one occasion with his repair steamer, and realizing that he was in the vicinity of the spot where a stretch of cable had been lost by another company's steamer some time previous, the captain set to work, picked up the cable within an hour or two, and delivered it to its owners on his arrival. Two of the Atlantic cables were grappled, hauled up, and repaired in mid-ocean last summer. It is expensive work, sometimes costing two or three hundred thousand dollars.

There are now throughout the world over 116,000 miles of submarine cables, with nearly 125,000 miles of conductors. Only in short cables can more than one conductor be used. That is to say, two wires, each insulated from the other, cannot be operated in long cables on account of a cross-fire known as *induction* between them. Hence, the mileage of cable is almost as great as the mileage of conductors. The Eastern Cable Company alone owns ninety-one cables, extending over 38,000 miles.

I presume you have all seen specimens of submarine cables, and many of you are more or less acquainted with the general method of their construction. It would be outside the object of this paper to describe the various forms. There are several extensive manufactories, each having its own style of construction. The chief objects for which manufacturers have striven have been great conductivity, high insulation, tensile strength, and small bulk. To this end generally the conductor is made of several copper wires twisted together as one. A single conductor of the same amount of metal would be too risky, for if it should break, continuity might be lost beyond repair for a long time. Injury to one of the small wires forming the composite conductors would not seriously interfere. The copper forming the conductor is always of the purest. Then comes the insulation. Unless a cable conductor is well insulated, or protected from the water, the electric current, instead of making itself manifest at the distant end, will leak out into the water and complete a circuit through the earth to the point from whence it came. For it must be remembered that the conducting wire, although made of the best conducting metal known, offers some opposition to the absolutely free passage of the current. This opposition, termed resistance, corresponds to friction. Now a cable from Ireland to Halifax has a pretty high resistance, amounting in some instances to twelve or fifteen thousand ohms or units of friction, while the entire earth only offers resistance of a fraction of an ohm, or equal to the resistance of about fifty feet of the ordinary telegraph wire that you see on the poles. Therefore, as electricity is a great economizer of distance and time, never going an inch out of its way, it will go through a fault in the cable in preference to coming over to America. A hole in the protecting shield as big as the point of a pin will let the current out, and if it once gets started, even in a very small way, it will soon make an outlet for itself that will practically put a stop to all telegraphy. This will give you some idea of the necessity for perfection in the manufacture of cables. Of course, the full coating of insulation is not put on all at once. Three or four different coats are applied. Gutta percha and compounds of a kindred nature are used. Tarred hempen twines are wrapped around the insulation. Then galvanized iron wires are twisted over the hemp, and sometimes they, in turn, are wrapped with fibrous material to protect them from the corrosive action of the water.

All cables are tested before leaving the factory. When put on shipboard, the ship's electrician is in constant communication with the shore through all the cable on the ship. The slightest fault is detected just as soon as it goes into the water. Paying out is immediately stopped, and the cable repaired. You could not see a pinhole in the insulation, but it can be located by the fine testing instruments, sometimes within a quarter of a mile in the entire stretch of 2,000 miles.

The best conductor is the worst insulator, the best insulator the worst conductor. The difference between the conductivity of pure copper and gutta percha cannot be expressed understandingly in figures. Somebody has calculated that if the difference was reckoned on the basis of the velocity of light, it would take the sunlight a century to reach the earth. Owing to great insulating properties of gutta percha, but a fraction of current is lost between Europe and America.

People unacquainted with these matters would naturally think, with DeSauty, that so long a cable would require very powerful currents to operate them, but it is not so. There is quite as much battery used in working a wire between Philadelphia and New York as is used on the cable. The reason is mainly on account of the almost perfect insulation of the latter, little or nothing being lost, while in the case of the Philadelphia and New York overhead wire a large percentage of the current goes to earth at the poles. Besides, much coarser instruments are used on the land lines. It would injure the Atlantic cable to apply as much current power to it as it takes to work a land line from New York to Washington on a rainy day. All the current that goes into a well insulated cable at one end must come out at the other. It would be much better if the insulation of the cable was less perfect. It could be operated much faster. My own opinion is that the great need in cable telegraphy is bad insulation, or a *good bad* insulating material—something that will not go from bad to worse under the action of the current. Just at this time there is considerable discussion going on as to the necessity for armor wires for deep sea cables, and also regarding their effect on the working of the cable. It is claimed by many that there is absolute rest at the bottom of the Atlantic, and that tarred hemp covering would be more durable than the armor wires. Many electrical authorities have held that iron armor wires impede transmission, on account of their influence on the conductor, or magnetic induction.

The greatest living authority in such matters, Sir William Thomson, lays down the law that while the retarding effects of magnetic induction may be recognized in cables of about 100 miles in length, it is completely overshadowed in long cables by the greater retardation arising from static capacity. He even goes so far as to accept and indorse Mr. Oliver Heavesides' mathematical proof that magnetic induction increases the speed at which long cables may be operated.

While it would be great presumption for me to differ with such eminent authority, I cannot help thinking that there is much of what Professor Tyndall would call "scientific speculation" in these views. I am strongly of the opinion that the unarmored cable would be much faster than the one bound with armor wires. Aside from electrical considerations, it is believed that armor wires are necessary to protect the cable from chafing on the rocks and from the teeth of the parasite which fares sumptuously on hemp, tar, gutta percha, and other apparently indigestible substances. Everything is said to have its parasite, and it is proved that cables at the bottom of the ocean have not been overlooked. Cables have been taken up from a depth of a mile and a half, with the hemp covering badly eaten away, and at a depth of over half a mile strong currents of the ocean have rasped the armor wires on the rocky bottom. To overcome this latter difficulty the shore ends of cables are always made much heavier and stronger than the deep water cables. Experience has not yet determined the full lasting qualities of electric cables. Specimens have been taken up which show no signs of deterioration after having been in the water for more than thirty-five years. Water, and especially salt water, seems to be a preserver of insulating compounds.

The method of operating cables has been so fully and learnedly explained in many books on electricity, that it may seem a waste of time to go over the ground in a less instructive way, but I do not intend to attempt more than a description, in simple language, of the elementary principles of operation, hoping thereby to be able to make clear to your minds the nature of my own endeavor in the direction of improvement, and in what respect it differs from the present plan. Almost everybody in these days has some knowledge of how land lines are operated. They have become accustomed to seeing the operator manipulating his key, and although the click of the sounder has no meaning to their ear, still all know that the working of the key at one end of the line causes the sounder to work at the other end.

Although not a country in Europe, except England, uses the sounder, the clicks recorded in dots and dashes on the strip have the same meaning. It

* A lecture delivered before the Franklin Institute, Monday, March 11, 1889.

is the only real Volapuk language. The marks on the paper might be likened to the music score, while the sounder is the tune itself. We are admonished that we should believe nothing that we hear and but half that we see, but experience has proved that in telegraphy the ear is more correct than the eye. Furthermore, telegraphy can be carried on much more rapidly by sound than by reading from the paper strip. We should be proud of the expertness of our American telegraph operators, for I doubt if there be on the entire continent of Europe an operator that could copy thirty words per minute by sound for five consecutive minutes. Our operators have to do this, or very near it, all day long.

It is not the fault of the foreign telegraphists that they are not sound-readers. They are, in the main, well educated, bright and intelligent, but the administrations have no confidence in this way of working, and refuse to trust it.

It was forbidden in this country up to about twenty-five years ago, but Young America could not plod where he could just as well progress, so the telegraph managers soon found that they were simply wasting paper. The operators read by sound.

On long cables, such as those across the Atlantic, the Morse relay and sounder are too coarse for the exceedingly delicate impulses that come through the cable. It might be possible to work a very sensitive Morse relay, but at an impracticably slow speed of perhaps two or three words per minute. The cable would be clogged up by the strong currents required. The weaker the current, the faster the speed; hence everything depends on the sensitiveness and delicacy of the receiving instrument. The most sensitive of these is the Thomson reflecting galvanometer (Fig. 1). It consists of a small piece of steel, no thicker than a watch spring and about three-eighths of an inch in length, suspended by the finest silk fiber in the center of a coil of fine insulated copper wire. To this small steel compass is fastened a looking glass, about as large as the blunt end of your lead pencil. Opposite this needle and its reflector, and perhaps three or four feet away, is a lighted lamp and a screen. In the center of the screen is a neutral or zero point, where the beam of light reflected by the small looking glass rests when there are no signals coming. A permanent magnet is placed in such magnetic relation to the small piece of steel as to cause the beam of light to return to the neutral point quickly after having been carried to the right or left by an impulse of current coming over the cable.

Instead of using a single key and making dots and dashes with a current of one polarity, merely tapping the key for a dot, and holding it down for a longer time for a dash, as in ordinary Morse telegraphy, the present cable system requires *two* keys, one connected to a positive, the other to a negative battery. Now, assuming that a tap on the positive key will swing the beam of light to the right in Canada, that signal would be recognized as a dot. Then, if the other key connected to the negative battery be tapped, the beam of light will swing to the left of the zero line and will denote a dash. You will observe that no dashes or long contact with the battery are admissible in this system, and the aim of the operator must be to make the taps on each key of the same duration, so that the reading light will return to its neutral position quickly and uniformly after each signal. This is the fastest system of ocean telegraphy in use.

The receiving apparatus is placed in a darkened room. The receiving operator calls off the letters one by one to a copyist who writes them down. It is tiresome work for the receiver, whose eyes must never leave the moving ray silently speaking to him from the other shore. To verify a letter of doubtful sound, a familiar word beginning with the letter is quickly pronounced. For example, after calling out the letter D, the receiver might say "dog," so that the copyist could not mistake D for B, C, G, or E. The average speed of transmission by this system is about fifteen words per minute for regular messages. A later and preferred system of cable signaling now in very general use is the Thomson recorder system. The signals are recorded in ink on a paper strip. Although not quite as fast as the mirror system, and a little less sensitive, the recorder is recognized as a marvel of ingenuity and perfection, considering the work it performs under such difficult conditions. This rough diagram on the screen (Fig. 2) will show the arrangement of the transmitting keys and connections. Everything is the same as already described in connection with the mirror system, but I wish to make it perfectly clear to you by the diagram, as it is between this system of transmission and my own system, which I am coming to soon, that I wish to draw a few comparisons. This diagram also gives an outline of the Thomson recorder. In a few minutes I will show you on the screen a recorder complete. Referring now to the diagram before us, you will have no difficulty in following the circuit connections. We must assume that the recorder is at the distant end of the cable, and the keys, batteries and condensers are at the transmitting end. In their present position, both transmitting keys are disconnected from the battery, and the cable is connected to earth. As but one key is pressed down at a time, the cable is connected to earth between each impulse. Now with the complete drawing of the recorder before us (Fig. 3), we can understand how the signals are received on the paper strip.

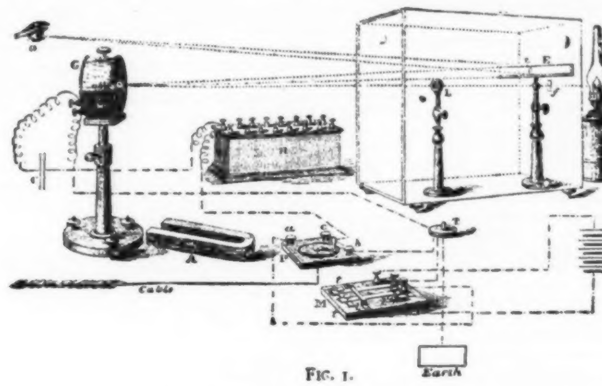


Fig. 1.

Instead of a small piece of steel suspended in the center of a coil of wire, as in the case of the mirror instrument, we have here a small coil of wire suspended between the two poles of a powerful permanent magnet. The wire in this small coil is so fine that several pieces of it might be put in the eye of a cambric needle at the same time. It is suspended by a very slender silk thread. To the bottom of the coil two weights are attached, which bring the coil into proper relation with the lines of force of the permanent magnet, so that when an impulse is received from the distant end it brings about the greatest amount of swerve of the coil in a rotary direction. When the current swings the coil to the left, the right hand weight pulls it back, and *vice versa*. The siphon, with one end in the ink pot and the other resting on the paper strip, is attached to an adjustable support, and its lateral movement is controlled by a silk thread attached to the coil. Now, if the paper be pulled by the feed rollers, a straight, delicate line in ink would be made in the center of the strip. But with the siphon touching the paper, the friction of even this very delicate contrivance would be too great to be overcome by the swing of the coil under the influence of the faint impulses coming over the cable. To remedy this, Sir William Thomson devised a plan of surpassing beauty and ingenuity. This mysterious-looking little arrangement, which you see here at the top of the figure, is a generator of static electricity.

It is frictional electricity, the same as you get from belts in your works, or from sliding your slippered feet across the carpet, the oldest electricity of which we have any record, unless, perhaps, it be the lightning that Ajax challenged. The Greeks made it by rubbing amber. Well, this is what Sir Wm. Thomson uses to relieve this little siphon of friction in its oscillations. The static generator is run by a small electric motor generally known as a "mouse mill." The electricity ground out by this little mill is conducted by a damp string or wire to the ink in the ink pot, which is well insulated from the base. It then finds its way though the ink in the small glass siphon to the paper, where it is discharged. The siphon, which is as fine as a hair, is normally adjusted so as to just escape the paper. The static electricity attracts the siphon to the paper, but as soon as the ink touches the paper the current is discharged, causing the siphon to rebound. Thus, the siphon may not really touch the paper, but the ink is deposited in dots so close together as to form a practically continuous line. The discharge and consequent vibration of the siphon will number, perhaps, fifty per second. In this way the small coil of wire meets with little or no hindrance in its movement and a permanent record is made on the strip which, if obscure or doubtful, may be scrutinized with deliberation. Not so with the mirror receiver. If a letter or word is not translated while the beam of light is swinging, it is lost and must be repeated.

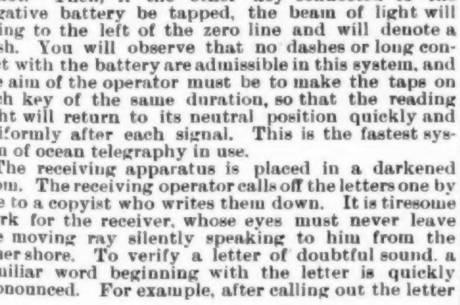


Fig. 2.

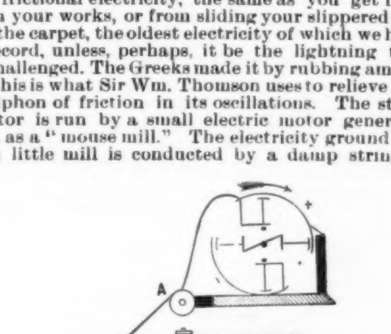


Fig. 3.

This beautiful electro-static device for overcoming friction has but one drawback. It is quite difficult to confine the static current to its proper channels in damp weather. Its high potential makes it difficult of insulation. Mr. Cutriss, mechanician and electrician of the Commercial Cable Company, has devised and put in operation a very ingenious plan for obviating this difficulty, and it does it most successfully. Instead of a static generator such as described, he fastens to the end of the siphon where it touches the paper a piece of iron about the size of a pin's head. Underneath the paper is an electro-magnet, the circuit of which is interrupted by an adjustable automatic vibrator.

In this way the small speck of iron attached to the siphon is attracted each time the circuit of the magnet under the paper is closed, and a vibration imparted to the siphon corresponding with the rate of the automatic circuit breaker, or, to be more correct, the circuit breaker is adjusted to the natural rate of vibration of the siphon.

Now, having considered the method of operation, we may analyze briefly the theory involved.

I will submit a few general propositions upon which to predicate a few deductions later.

The reason why relays and sounders are not used for cable work is that they require comparatively strong currents to affect them. Strong currents cannot be used, because they are injurious to the cable and prevent rapid signaling. The question arises then, is it possible to make a relay that will work with the present current pressure and make and break the local circuit of a sounder, so that signals may be received by sound at as high a rate of speed as at present obtainable by the mirror or recorder instrument?

It is a most hazardous thing in these days to say that anything cannot be done. I have no hesitation in saying that at no very distant day the Atlantic cables will be operated by relays and sounders, but not with the present system of transmission of the impulses. And I am also strongly of the opinion that the present mirror and recorder systems may also be operated at a considerably higher speed by a change in the method of transmission. Or, in other words, I maintain that the system of transmission which will make relays and sounders of the future work practically on long cables is now available for the improvement of the speed of the present receivers. I alluded some way back in this paper to obstacles in the way of operating cables with the same facility that land lines are worked. I now return to that part of our subject, and if you will continue your patient attention for a short time longer I hope to be able to make the cause and effects touched upon clear to you all. You all know the Leyden jar—that it comprises a glass jar with a coating of foil inside and another outside, each completely separated and insulated from the other by the glass. You also are well aware of the fact that if one of the coatings of metal be charged with positive electricity, the other coating will be inductively charged with electricity of an opposite polarity. It is the same with a condenser made up of sheets of tin-foil and separated from each other by sheets of paraffine or any high insulation.

A submarine or subterranean cable is nothing more than a Leyden jar or condenser. The conductor is one plate, the insulation is the glass jar, and the armor wires and water the other plate. Consequently, when a current impulse is sent into the cable, an opposing current makes its appearance on the outside and in the insulation. This unwelcome outsider weakens the real impulse in its passage through the conductor, and, worse still, takes possession of the conductor itself when the first current ceases, and opposes the entrance of the next current impulse.

Thus it is that, after each signal is sent into the cable, we have what is known as static discharge. It is only static, or in a state of rest, so long as the signal current is in possession of the cable, for when the cable conductor is put to earth, as is done after each impulse, as shown in the drawing, it runs out, most of it toward the end at which the signaling current went in, but some of it goes toward the distant end, prolonging the signal at the end much beyond its length at starting. Now, for the reasons already explained, currents, whether real or vagrant, travel slowly in the cable. It requires about one tenth of a second for an impulse to cross the Atlantic.

If the cable conductor was on poles fifty feet above the surface of the water, the impulse would make a dozen round trips in the same time. Now then, after sending in one impulse, the operator cannot wait for the static discharge to run out completely. This would render transmission unprofitably slow. Another impulse must follow, but, owing to the blocking up of the way by the static current, it arrives delayed and depleted at the other end. In cable telegraphy, as at present conducted, I have shown that two keys are used—one for sending positive currents, the other negative, and representing dots and dashes respectively. Now then, if the letter A is to be sent, the positive key is first tapped and the siphon is carried toward the top of the strip. Then the negative key is tapped and the siphon is carried toward the bottom of the strip. These two movements up and down will represent A, and there is no mistaking it. This letter was formed of alternations of the current—positive and negative. It will be different with letter B. It requires four signals—a dash and three dots. The negative key is pressed down once, and immediately afterward the positive key is pressed down three times in succession. Thus one negative current and three positive currents were sent. The effect of the negative impulse was to carry the siphon below the horizontal line representing the dash. The first of the three positive currents brought it back to a position slightly above the horizontal line. The second carried it a little further in the same direction, and the third still a little further. I have

on the screen several specimens of cable records (Fig. 4). Although the variety is not great, they are sufficient to show the effects of static capacity and retardation.

This 4-4 strip shows an alphabet in the Continental code, received over the Direct United States Cable Company's cable at Halifax from Ireland about three weeks ago. It is not a first rate specimen, owing to the fact that the cable is generally worked with the mirror system, and the recorder was set up temporarily by the obliging management just to get me this record. It is a fair sample of every-day cable work, however. This and the other strips on the diagrams which you have are one-third below the actual size, having been photographed down. You will see that the three dots of the letter B resemble three steps of a stair, but without the sharp outline, and you will observe that the last dot is less distinct than the second, and that the second is not as plain as the first. The dots in letter H answer the description even better than B. The explanation of this is that the first dot represents the scope of the swing of the suspended coil of wire under the influence of a reversal of the current from negative to positive. The second dot simply shows a slight fall in the potential of the cable, owing to the breaking of the current at the sending end, and the third shows a still smaller undulation. The cause of this is that, after the first dot was made and the battery withdrawn at the sending end, the static current continued to run out at the receiving end, still holding the siphon above the horizontal line, to which point it would otherwise have returned quickly, and in its exit at the transmitting end weakens the next dot coming in. The third dot shows that the cable was still more clogged up than when the second dot came through, and so on. If dots were sent continuously, there would be nothing but a straight line, provided the dots followed each other in reasonably rapid succession. It must not be inferred that additional dots would keep on carrying the siphon higher and higher, for such would not be the case. The maximum influence of the current for turning the coil around is reached in three or four impulses, and if the current was permanently connected, the siphon would make a straight line above or below the center of the strip, according to the polarity of the current coming over the cable.

You will readily appreciate the degree of proficiency and experience necessary on the part of the cable operator to translate correctly these wavy lines and almost imperceptible undulations, especially when we remember that nearly all cable messages are in cipher, without meaning or context to aid the operator. The high charges have been productive of codes so constructed that a single word may, when translated, be as long as the Lord's Prayer. Ten letters are allowed to a word. If it goes one letter over, it is charged for as two words. The addition or omission of a letter in a word may change the entire meaning of the cablegram. The cable operator must exercise wonderful judgment. When the dots or dashes are practically devoid of any characteristic but a straight line, he determines their number by the length of the line occupied by the doubtful letter. The strain on the mind is great, for fines are imposed for errors.

To facilitate business, and as a further safeguard against mistakes, in some offices two operators examine the strip as it comes from the instrument. The second operator verifies or corrects words indicated as doubtful by the first.

The most interesting and really wonderful telegraphing in the world is carried on by the Eastern Cable Company. Messages are sent from Bombay to Penzance over a series of cables which, by what is known as the "human relay" system, is practically continuous. Bombay sends to Aden, 1,832 miles. An operator at Aden reads directly from the strip, and at the same time transmits to Suez, 1,403 miles. Suez in like manner sends to Alexandria, 154 miles. Alexandria operator sends to Malta, 925 miles. Malta repeats to Gibraltar, 1,125 miles. Gibraltar in turn sends to Lisbon, 383 miles, and finally the operator at Lisbon sends to Penzance, 891 miles. A total distance of 6,713 miles without a word being written. This weird message of mankind enters ocean after ocean and sea after sea, bobbing up serenely at intervals, as though to get breath for a fresh dive. As nearly all cable circuits are worked upon the duplex plan in these times, this matchless transmission is not interrupted for corrections or missing words. The message is kept moving to the end, and if found wanting in any respect, inquiry is sent back to Bombay on the other circuit. So that the routine goes on like an endless chain.

I do not think it necessary to take up any further time with the theory and practice of the present system, but will come at once to an explanation of my own system of transmission, which I will endeavor to make as short as possible. I must ask you to give me your attention while I have recourse to this excellent diagrammatic view of the apparatus (Fig. 5), and if you will bear in mind what has already been said upon the theoretical operation of cables, it will take you but a few minutes to recognize the difference between the systems explained to you and the one I am about to describe.

The main features of this system are that successive impulses of the same polarity are never sent into the cable; that each signal impulse is followed by another,

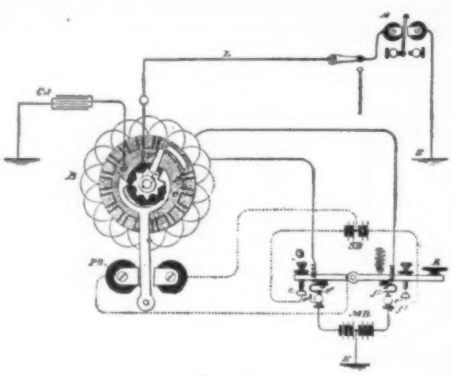


Fig. 5.

which opposes and neutralizes the static charge in the cable, and clears the way for the next signal impulse. Also that all the signaling impulses are of practically the same duration, and that the clearing impulses are absolutely of the same duration. And, finally, that transmission is done by the use of an ordinary Morse key, so that any operator can send messages. The two-keyed system requires even more practice to become proficient than single-key working.

(To be continued.)

A PECULIAR GROUND.

A short while ago an incident happened in connection with the Edison three-wire system under Boylston Street, Boston, which is interesting both to the electrician and the chemist. It was noticed that the horses were very uneasy and somewhat scared when passing over an area of say ten feet square in the granite pavement of the street. An investigation by the Edison people seemed to show no trouble, and everything went right for ten days or more, when, during a rain storm, the same action of the horses was noticed.

Upon digging down to the wooden box which contained the three wires of the system, embedded in some kind of tar or bitumen compound, a spot was found where the box was eaten through, and a large mass of sticky stuff was found around the negative wire. The insulation of the wire was destroyed, and as the neutral is dead grounded in the station there was a leakage, causing a fall of potential in the earth about the leak which was sufficient to affect horses as well as men. The leak was a small one and did not show at the station.

Chemical examination of the lump showed that it was originally concentrated lye which had become partly converted into caustic soda by water, and that the action of the currents had, by electrolysis, formed a considerable quantity of metallic sodium throughout the mass. There was sodium enough present to make a fair display of fireworks when thrown into a pool of water, and it is fortunate the workmen did not get into trouble in handling it.

My theory of the affair is this: In some way a piece of lye tumbled into the kettle in which the insulating compound was made, and was not noticed when the box was filled. In time surface water got at this lump and converted a part into caustic soda, which destroyed the box and insulation of the wire (it only came in contact with one wire, the negative).

The escaping current caused a difference of potential at the surface of the ground which disturbed the horses. Metallic sodium was set free and would tend to collect at the negative wire.

The voltage at the escape was in the neighborhood of 105 volts, and it was estimated by the touch that there was over 50 volts within the space that a man could reach with both hands.—*W. L. P., Electrical World.*

[Nature.]

JOHN PERCY, M.D., F.R.S.

By the death of Dr. Percy, on the 19th June, this country has lost a distinguished man, who has greatly influenced its metallurgical progress.

He was born in 1817, and at an early age entered the Medical School of the University of Edinburgh, where, at twenty-one, he took the degree of M.D. He subsequently became physician to the Queen's Hospital at Birmingham, and the few papers he published on medical subjects show that he would probably have risen to eminence in medicine had it not been for the fact that in the great metallurgical center of the Midlands his studies were soon diverted to the particular line of work to which his life was ultimately devoted. This is not perhaps surprising when it is remembered that the connection between therapeutics and metallurgy has been traditional since the days of Paracelsus and Agricola.

When we look back at Dr. Percy's career, the remarkable fact stands out that, notwithstanding the great importance of metallurgy to this country, with its vast industrial interests, there was no metallurgical treatise worthy of the name until he wrote one; and, what is stranger still, up to the time when he accepted the chair in the Royal School of Mines, in 1851, there was no systematic teaching of metallurgy. Dr. Percy found it practiced mainly as an empirical art. Sir Henry de la Beche indicated the direction the teaching had to take, and in his inaugural discourse as director of the School of Mines, he said, "We still too frequently hear of practical knowledge as if, in a certain sense, it were opposed to a scientific method of accounting for it, and as if experience without scientific knowledge were more trustworthy than the like experience with it." Reference to the pages of the Journal of the Iron and Steel Institute will show that this, the most practical body of men in the world, not only thoroughly recognizes that mere empiricism would be fatal to industrial success, but constantly appeals to science for guidance. This is in great measure owing to Dr. Percy's teaching, and is not the least important of its results.

Ten years after he began to teach, he published the first volume of his treatise on "Metallurgy," which he dedicated with "sincere respect and affectionate regard" to Faraday. This work, which he calls the "task of his life," has developed into a series of volumes containing 3,500 octavo pages. One remarkable feature of these books is that almost every woodcut may be regarded as an accurate, though small, mechanical drawing, and it is only measurable drawings of this kind which are of real utility in practice. Treatises such as his naturally embody descriptions of processes furnished by those actually engaged in conducting the operations—aid which was always most fully acknowledged. The thoroughness of his own research is well shown by the careful digests of monographs, which were gathered from all kinds of sources; and it is evident that immense pains were bestowed upon the work. Some years ago a foreign friend, himself a laborious and conscientious author, forcibly expressed to the writer his appreciation of Dr. Percy's labors, looking up from one of the volumes and exclaiming, "*C'est enorme ce qu'il a compilé.*"

It may perhaps be admitted that his intolerance of inaccuracy at times led him to magnify points which now seem to be somewhat trivial, and he sometimes withholds the expression of his own opinion when the reader has fairly a right to expect it, and would be grateful for the support of his authority.

With the notable exception of a process for the extraction of silver from argentiferous ores and residues, he can hardly be said to have originated any important metallurgical process; but his works teem with suggestions, and many improvements in metallurgical

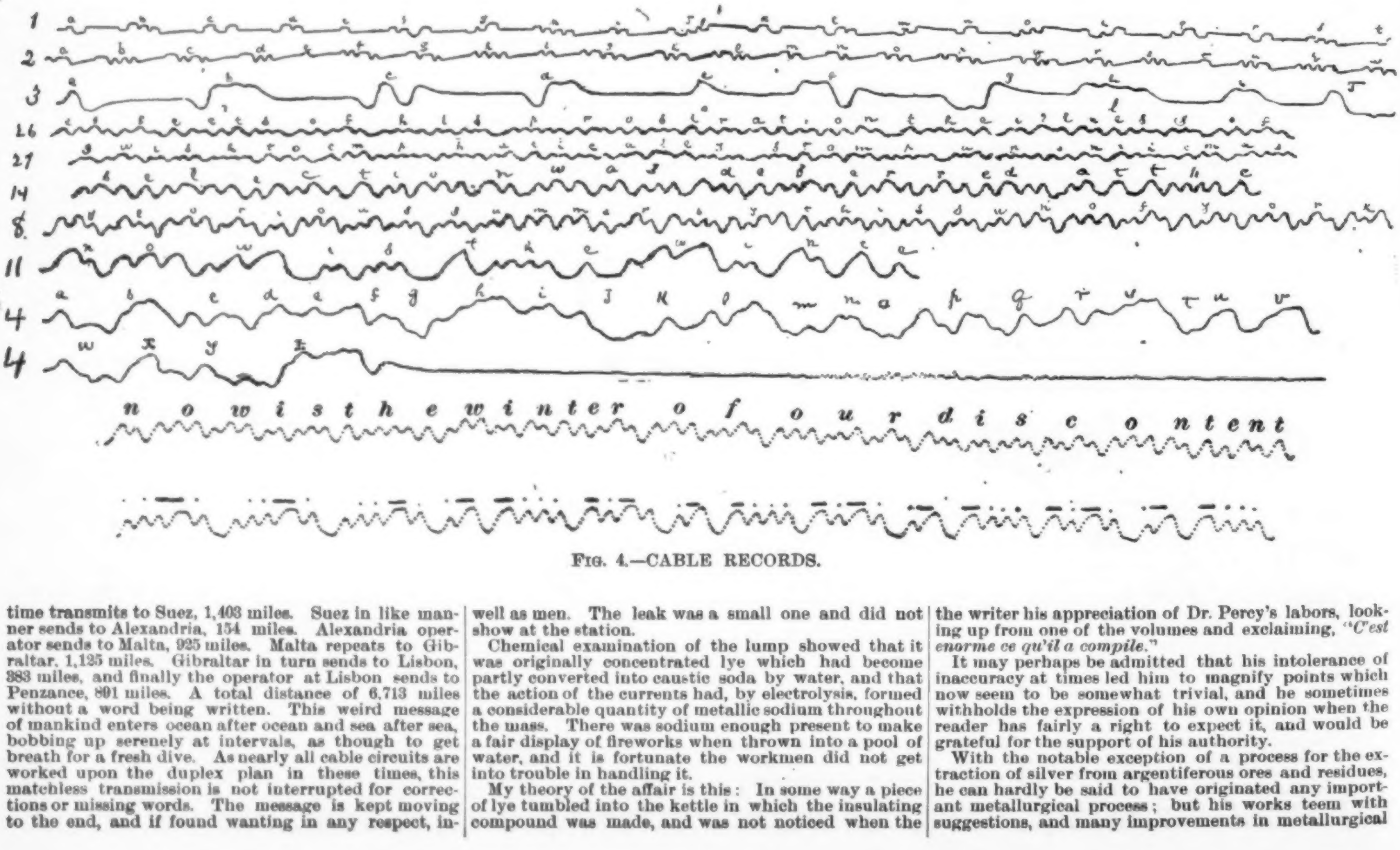


Fig. 4.—CABLE RECORDS.

practice can be directly traced to his teaching. Such is the case with the practical application of the basic process for eliminating phosphorus in the Bessemer converter—a process of truly national importance, and one which has been widely adopted in other countries. It may fairly be claimed that during the thirty years he held his chair he trained a body of scientific workers in whose hands the immediate future of metallurgy to a great extent rests.

Remarkable evidence as to the strength of his individuality is afforded by the fact that those who were admitted to his friendship, and even his students who only saw him in the lecture room or laboratory, were all singularly attracted to him, notwithstanding the occasional ruggedness of his manner. The purity of his style and the quaintness of his illustration recall the writings of another doctor, Sir Thomas Browne, making, of course, due allowance for the difference of the periods at which they wrote. The subjects he dealt with were very diverse, and it would be interesting to collect his trenchant letters, which appeared in the *Times*, usually over the signature Y. One especially occurs to the writer. Dr. Percy was charged with the superintendence of the ventilation of the Houses of Parliament, and amusingly describes his difficulties in meeting the varied and often contradictory requirements of the members, as to the temperature best suited to their work. He was an honorary member of the Institution of Civil Engineers, and held the office of President of the Iron and Steel Institute in 1885, having received the Bessemer medal of that Institute in 1877. His artistic skill was considerable, and he possessed a fine collection of water color drawings.

Two days before his death the Prince of Wales awarded him, on the nomination of the Council, the Albert medal of the Society of Arts. Dr. Percy was still able to appreciate the honor which had been done him, and received the intimation with the characteristic words, almost his last, "My work is done."

W. C. ROBERTS-AUSTEN.

"HAY FEVER"—PERIODIC CATARRH.*

By Dr. G. ARCHIE STOCKWELL, F.Z.S. (Member of New Sydenham Society, London), Detroit, Mich.

"CIVILIZATION by its advancement constantly entails new ills to mankind," is an assertion of many philosophers, ancient and modern. Democritus long before our era formulated it as an axiom, and that it is not without a measure of truth is evidenced by the accessions to our medical nosology and nomenclature.

It is only within three-fourths of a century that the distressing malady popularly and erroneously denominated "hay fever" or "hay asthma" has been recognized as a malady *sui juris*, or that it has attained sufficient prominence to secure a place in medical literature. That it is distressing, every one must admit who has been brought in contact with its victims, or who has suffered from its paroxysms. Then, too, it is almost despicable, since, in spite of the suffering it entails, it possesses none of the elements that can be considered as dangerous or threatening to life, which might in some degree console its victims by exciting the sympathy of the exempt; but instead it is self-limited, both in course and recurrence, even though, chameleon-like, its manifestations are seldom exactly twice alike in the same individual, and seldom attended with the same precise phenomena in each season. Its phases are as multiple as its victims, and as numerous and varied as the meteorological caprices of its environment.

Absurd and paradoxical as it may appear, the malady stands in *locum tenens* of a luxury, and, like all other luxuries, its obtainance is accompanied by no little personal sacrifice and cost, for it is dearly paid for by all unfortunate enough to come within its pale. Then its recurrence tends to inculcate habit, since it fastens more firmly, and becomes more and more exacting, with each season. The evidence of this rests in the fact that if the attacks are anticipated for several seasons in succession by removal to those regions without its pale, the force of the annual habit is lessened, and while the tendency may not be altogether obliterated, the acuteness of the paroxysms is notably mitigated for a considerable period.

Again, no age is exempt. [Moulton observed in a child eight years old,† and Wyman in one three years younger.‡] It prefers the temperate to the torrid zone, altogether ignores the Far North, where the intense heat of the brief summer would seem to invite its appearance and residence; dreads the highlands, with their rarefied air; and hates the vicinity of large bodies of water with all the intensity "Auld Clootie" is supposed to manifest toward the church font. It chooses the city in preference to the country and forests; seeks out the man rather than his helpmate, though the fair sex are not wholly exempt from its terrors; and in whatever part of the world it appears, the victims are almost exclusively selected from among the Anglo-Saxon, or at least the English-speaking race. Moreover, it is aristocratic as well as autocratic in tendencies, since it exempts the poor, ignorant, rude, and lowly, to prey upon the wealthy, the gentle, the sedentary, and the intellectual; it is the bane and curse of the courtier and the mock and jest of the clown.

The origin and history of periodic catarrh are alike shrouded in uncertainty and obscurity. In the early part of the present century [1819] Dr. John Bostock, himself a sufferer, described the disease under the name of *catarrhus aestivus* or "summer fever" in the *Medico-chirurgical Transactions* § of Great Britain. Nine years later, a second communication from his pen appeared in the same periodical, that, if it did not offer new facts, at least evinced the accessions that had occurred to the malady as manifested in himself. In this second essay ‖ he incidentally mentions it as a "hay" fever, a pseudonym that was immediately adopted, under the supposition that pollen of grasses were the immediate etiological factors. The title thus unintentionally bestowed was perpetuated in good faith by Mr. Charles Blackley of Manchester, who (in 1873) contributed an extensive monograph upon the subject,* and boldly asserted that the disease depended for its source upon the ripening of the *graminaceæ*, since he could "conceive of no other cause." In this he followed not only the teachings of Bostock, but of Gordon [1829], Elliotson [1839], Abbott Smith, Pirrie, and Moore [1859]; and if I mistake not the same obtained in the teachings of Morrel Wyman [now a recognized authority on the subject] in Harvard in 1854, and perhaps later, though he early discovered good grounds for abandoning the theory. Elliotson opined the offending growth was *Anthoxanthum odoratum*, basing his views upon the fact it flowered in Great Britain at about the time "hay" fever is wont to manifest itself; others ascribed it to *Anthemis macula*, and elaborate arguments were offered from time to time to sustain these positions. The fallacy in both instances was proved in the United States, where these plants are alike common, flowering in May or June, while the disease, save in some few instances, does not manifest itself until the middle or latter part of August. It will be observed that "hay" fever in England recurs in midsummer or in June or July, and is the analogue of what on this side of the Atlantic is termed "June" or "rose" cold; and while the flowering of *Anthoxanthum* and *Anthemis* corresponds to the period of the malady abroad, in the New World there is a discrepancy of from nine to thirteen weeks between the production of pollen and the onslaught of periodic catarrh. Again, farmers, farm laborers, florists, gardeners, hostlers, and stable boys, people whose callings especially tempt the malady, were grasses at fault, are rarely or almost never its victims. In an experience of nearly a quarter of a century, I cannot recall a single instance in practice or in periodical medical literature. Still, the general impression, not only among the laity, but a majority of the medical profession in Great Britain, appears to be that the malady as found there is intimately connected with the harvesting of grasses, and that if the latter are not producing causes, they at least intensify the paroxysms, as may be judged from the fact that so eminent a man as Dr. F. De Havilland, F.R.C.P., of Westminster Hospital, writes to the *British Medical Journal* [June 15, 1889]: "The return of the hay season and the prospect of their being an unusually abundant crop this year has induced me to direct attention to hay fever, which is a subject of ever increasing interest." Again, Doctor Bertram C. Windle, Professor of Anatomy at Queen's College, Birmingham, remarks [*Birmingham Medical Review*, December 1888]: "As to the cause of the disease, I have no doubt in my own mind that pollen of some kind or another—almost certainly that of some grass or grasses—is to blame." In this country, however, "rose" cold, "June" fever and cold, etc., are titles suggested by the idiosyncrasies of individuals who may suffer a real coryza or asthma as the result of habit or from a hypersensitiveness of the respiratory apparatus that induces this condition when brought in contact with the leaves, flowers, pollen, etc., of certain trees, shrubs, or plants; the down of rose petals or leaves, or "fuzz" from the skin of the peach or rind of muskmelon is often at fault, and in some localities the pseudonym of "peach" cold obtains. Those who suffer from "June cold" often escape the autumnal coryza which is the most common form, while others suffer from both, with a brief period of relief intervening.

Rag weed [*Ambrosia artemesiæfolia*] is generally accused of producing periodic catarrh or coryza, and while the supposition has no basis in physiology or fact, observation and experiments that have been made with a view of determining the exact relation of this growth evidence its complicity oftentimes, not as an original or producing factor, but in intensifying and accelerating the course and paroxysms of the malady. The evidence is such that in the light of the public weal, municipalities should at least take measures to repress the blossoming of rag weed within their boundaries and to prevent its growth.

Among other theories that are worthy of mention is that of Helmholz † [advanced in 1869], who suggests the presence of vibrios in the nasal cavities, that remain dormant during the winter and spring months, but are gradually warmed into activity by the heat of summer. Strange to say, at this time, when the microbe theory is rampant and held the derivative of all maladies from warts to ague and salt rheum to cerebrospinal meningitis and diphtheria, no one has as yet availed himself of the broad field for research afforded by periodic catarrh, which is still "going a-begging" for a *coccus*. The hint herewith thrown out is offered gratuitously to some enterprising pathologist.

Thus far I have employed the name *periodic catarrh* as indicative of the malady known as fever, asthma, catarrh, coryza, cold, etc., with all the adjective denominations of "hay," "summer," "ragweed," "pigweed," "peach," "August," "pollen," "idiosyncratic," *et al.*, but the title is inappropriate and inexact, for, as already shown, the same precise symptoms and paroxysms manifest themselves at different seasons, in different localities and in different individuals, and moreover is not in all instances strictly periodic.

The proposed compromise of Dr. Phoebus,‡ who suggested the title of *fruhsommer katarrh*, "summer catarrh," is also open to objections, since, contrary to general and preconceived opinions, the malady may, and sometimes does, manifest itself in midwinter. One of the most interesting cases from a medical standpoint that has ever come to the knowledge of the writer was found in the person of an English gentleman who, though not a medical man, is well known to science [Richard Proctor]. The asthma, for it partook of this form, occurred only during the cold months, and was always aggravated by a rime or hoar frost, especially if the latter was followed by a bright, sunny day. To employ the gentleman's own words narrating the history of his malady, for many years prior to the first attack he suffered from a cough; used to catch periodical colds, and with true cold came along acute asthma, when he was very much distressed; since the asthma became chronic [attended by constant paroxysmal sneezing, coughing, phlegm, and eyes inflamed and watering], he has scarce ever had a real cold.

All that is denominated autumnal catarrh, "hay" fever, or "hay" asthma, however, is not properly of the class to which they are popularly assigned or to which these terms are intended to apply. Many are in reality pseudo cases, dependent upon abnormal growths and hypertrophy or thickening of the mucous lining of the throat and nasal cavities, conditions easily removed, and that, once remedied, prevent further accessions of paroxysms. It is not known that polypoid growths tend notably to the production of asthma and other conditions that precisely resemble those induced by periodic catarrh. Indeed, many of the more common asthmatic and bronchial affections arise from conditions no way pertinent, in fact grossly irrelevant, to "hay" fever, so called. Within a year, in the experience of the writer three cases supposed to be "hay" asthma were permanently relieved by the removal in each instance of numerous small polypi attached to the posterior border of the nasal septum. It is not necessary, however, to here dwell upon this part of the subject, since at best it is but a side issue, and will be referred to again further on in considering methods of relief. All these facts, however, including the recurrence of asthma and coryza at different periods in certain individual cases, lead the way to the conclusion that the true "hay" fever so called is simply an idiosyncratic, paroxysmal malady, of nervous origin, and induced through the series of nerves [vaso-motor] distributed over the coats of blood vessels. Hence J. N. Mackenzie * suggests as an appropriate title *vaso-motor coryza*. But, although this theory is generally accepted by modern physiologists and pathologists, the entire truth has not been told, since it is almost of too great dimensions to be grasped in its totality by ordinary comprehension, and the medical profession, to a certain extent, are in the position of the three blind men in the fable of Tolstoi, who, having mastered a fraction, imagined they had grasped the whole.

Sir Andrew Clarke undoubtedly struck a key note when in the Cavendish lecture [*British Medical Journal*, June 11, 1887] he emphasized the doctrine that the evolution of vaso-motor coryza embodies three great factors:

First.—A nervous constitution or idiosyncrasy, sometimes inherited, sometimes acquired.

Second.—A local condition of irritability, involving the nervous, vascular, and cellular constituents of the affected parts, and which, when excited, disturbs the chemical, morphological, and secretory changes taking place therein.

Third.—External exciting or determining causes, *i. e.*, the agents which are capable of calling into action the irritability of the parts concerned.

The first of these is so vague, and so little susceptible of any direct treatment, that to discuss it in a paper of the character of this is impracticable. In considering the second factor, viz., the condition of irritability of the mucous membrane, it must be remarked that in spite of the advances made in the study of this affliction, no matter whether it asserts itself as a vaso-motor coryza or as an asthma, the interior of the nose receives too little attention; the treatment had been objective rather than subjective. This much, however, is recognized:

When local irritability is provoked into action, then arise series of local structural changes which are characteristic of the onslaught of the malady. The erectile tissues of the nasal passages and posterior throat become distended, the blood vessels are gorged, groups of lymph cells fill the lymphatic spaces, the mucous surface is crowded with migrating leucocytes [white blood corpuscles]; younger epithelial cells are vacuolating and proliferating, secretion is increased in quantity and altered in character and composition, sensation is heightened, intensified, altered, or benumbed, and the whole metabolism of the affected region is profoundly disordered.

As regards the third factor, there is, of course, as already remarked, an overwhelming weight of evidence in support of the view that pollen and other plant or fruit products are the most potent of external exciting cause. It is contended that the disease may be prevented from developing, or be cured when present, by dwelling on board ship at sea, where no pollen is to be found. That it obtains both as "June cold" and "autumnal coryza" only during the season when certain flowers or grasses are in blossom, and that it may be artificially induced in the immune and exempt by the application of the blossoming products to the nasal mucous membrane. Mr. William Murrell,† of Westminster Hospital, London, cites as the most guilty plants not only the *Anthoxanthum odoratum* ["sweet-scented vernal grass"], but *Bellis perennis* [the common "daisy" of England], *Lolium perenne* ["rye grass"], and *Holcus odoratus* ["sweet-scented soft grass"], while in India, where the malady occurs chiefly in February, it is the blossoms of the mango tree [*Mangifera Indica*] that are held responsible. Again, in the United States I have known Indian corn [*Zea mays*], flax [*Linum usitatissimum*] and millet [*Panicum miliaceum*], as well as "pig weed" or "goose foot" [*Chenopodium album*], "hog" or "rag" weed [*Ambrosia artemesiaefolia*], and "smart weed" [*Polygonum hydropiper*], and the *Rosaceæ*, each and all to be accused. Miss G—— B——, of Boston, informs me that during portions of June and July, and also of August and September, she is unable to approach a rose tree, to remain in a room where the flowers are, or anywhere in their immediate vicinity, without the most distressing paroxysms being induced, though after the advent of frost, and until the next succeeding June, their odors may be inhaled with impunity. Mrs. J. W. S——, a former patient, is equally susceptible, and Trosseau was in like manner affected by violets.

Now, while it must be admitted that these contentions are in some degree just, and that plants are common sources of aggravation [and perhaps in some instances the immediate cause of the disease], it cannot be denied that they lack qualifications, and that they are inadequate to a complete explanation of *all* the facts which go to make up the history of the coryza and asthma. In looking closely into the matter we find the supposed provocations as numerous almost as the individual sufferers; also, that persons free from the malady obtain attacks simulating "hay" fever from certain idiosyncrasies. For instance: Cullen ‡ re-

* Read before the Western Hay Fever Association at Petoskey, Michigan, Aug. 27, 1889.

† "Cavendish Lecture," *Br. Med. Jour.*, June 11, 1887.

‡ "Autumnal Catarrh," by M. Wyman, Boston, 1876.

§ Vol. x., p. 161.

‖ Vol. xiv., p. 437.

* "The Causation of Hay Fever."

† Virchow's *Archiv*, vol. xlvi., part 1 (Feb., 1869), p. 101.

‡ "Der Typische Fruhsommer Katarrh oder das sogenannte Heufieber, Heuasthma." Giessen, 1862.

* *American Journal of the Medical Sciences*, July, 1883, and *New York Medical Record*, July 19, 1884.

† *British Medical Journal*, June 16, 1888.

‡ "Practice of Medicine," London.

fers to a case in which the most intense agony was induced by the vicinity of a rice-thrashing floor, regardless of the period of year at which the grain was separated from the husk. Sir Thomas Watson says:[*] "I recollect a servant employed in the laboratory of St. Bartholomew's Hospital who had the peculiar ill luck to be liable to this affection when in the presence of ipecac, and whenever this drug was in preparation he was obliged to fly the place, and this idiosyncrasy is by no means uncommon." William Smith[†] records instances of "hay" fever provoked by linseed meal and by mustard; William Murrell,[‡] by powdered colocynth ["May apple"], the effluvia of a clean pocket handkerchief fresh from the ironing table, locust tree blossoms, mulberry blossoms and fruit, etc.; Sidney Ringer,[§] by the exhalations of monkeys, dogs, cats, horses, rabbits, Guinea pigs, cattle, and wild animals. Hyde Salter[‖] tells a story of a clergyman in whom an attack was always induced by the vicinity of a dead hare, and hence was always able to detect a successful poacher. This gentleman once had a severe attack in consequence of a hare skin placed under his sofa as a joke. H. Charlton Bastian, also, in the *Philosophical Transactions*,[¶] relates like effects as invariably produced on himself while working at the anatomy of the *Ascaris megalocephala*, or "mange" insect of the horse. Ringer and Murrell report the case of a gentleman, aged 24, many of whose relatives suffered from "hay" fever, one sister being a "cat asthmatic." He was always made worse by the vicinity of a horse, or persons that had been about stables, and one night an attack suddenly supervened in a theater, without any appreciable reason, until suddenly a horse galloped on to the stage, when he was forced to leave the building.

The following case taken from Ringer and Murrell[**] is unique. A gentleman of neurotic temperament, about the age of 50, suffered from acute pleurisy, the result of exposure to cold and wet while out shooting, and ever afterward was subject to what he called "hairy caterpillar asthma." If by any chance he touched a caterpillar, especially a very hairy one, he was immediately seized with a "hay" fever paroxysm lasting an hour or more, and that began with sneezing, itching, and irritation of the eyes and nose, with profuse watery discharge from both. He was not in the slightest degree affected by pollen, and could pass hours in the presence of animals without inconvenience. One of his daughters was a "cat asthmatic."

Several cases of interest as showing the influence of light as an exciting cause are related by the same authors, and one is also a good example of what may be called mixed paroxysmal "hay" fever or coryza, the attacks being induced not only by pollen but by other causes. "The widow of a clergyman has suffered many years. The attacks occur all the year round, but are most severe in summer. They often occur the first thing in the morning, as soon as she begins to move in bed. They are excited at any time by grasses, roses, privet, and in less degree by other flowers. Driving in the face of a strong wind will always bring on an attack. Any dust, especially that of a bedroom, is equally efficient, and sunlight is also a frequent exciting cause. Food at once affords relief, even when no stimulant is taken, the symptoms subsiding before the meal is finished. She never catches cold in the head, and the chest is not usually affected. The attacks last from one to two hours, and are followed by great exhaustion, but are always aborted or relieved by going into a dark room. It is worth mentioning that her daughters suffer from the same complaint."[††]

These are exceptional cases which might be multiplied by citations from different authors. The ordinary "hay" fever or paroxysmal periodic coryza—which seems a more appropriate title—is of annual recurrence, and returns oftentimes on the same day each season, almost at the same hour, in each individual; in very few cases is there a variation of more than a few days. But it is not of equal severity in each year, since it is more or less dependent upon the character of the season and meteorological conditions; and in some never exceeds in severity a mild cold, while in others it is a most serious affair, perhaps attended with profuse expectoration of mucus streaked with blood.

About the 20th of August, usually, in the United States, the sufferer experiences an itching of the mucous membrane of the eyes, upper throat, and nostrils, which at times becomes so intense as to be almost unbearable, accompanied by inordinate and most comprehensive sternutations, and often without apparent cause, though frequently provoked, seemingly, by a bright light, cool current of air, or trifling exposure, such as tends to ordinary catarrh.

At first the paroxysms are infrequent and of moderate severity, but soon the intervals between the accessions are shortened and the manifestations become more and more violent.

Sneezing may begin while dressing or at breakfast, the attacks being prolonged, but unaccompanied by the grateful sense of relief that ordinarily attends such manifestations. Further, over-exertion seems to intensify the paroxysms and the feeling of discomfort induced; at the same time there is a slight acceleration of the pulse, with general slight febrile excitement, hence doubtless the title "fever" that obtains frequently with one or the other of the popular adjectives prefixed. In a week or ten days, probably, symptoms of bronchial irritation supervene, with dryness and injection of the throat, followed by a tickling cough that rarely results in any amount of expectoration. The latter, after a time, is more severe and paroxysmal in character, not infrequently inducing severe pain and soreness in the chest, which may or may not be materially relieved by the establishment of an expectoration. Like the catarrh or coryza, the bronchitis varies in intensity in different individuals, and also in the same individual in different years.

In many cases, after a most harassing experience, extending over ten days or a fortnight, both the coryza and bronchitis lose their severity, though by habituation they are likely to hang on more and more persistently with each succeeding autumn. In the former instance, the coryza entirely disappears, and while the cough and bronchitis may persist as a most exasperating tickling, especially toward nightfall and in the evening, convalescence gradually merges into recovery lasting until the next season rolls around, the whole course of the disease having lasted but three or four weeks. With the latter, and most old "hay" fever sufferers, especially if the gamut of sedative remedies has been well gone over, relief is only obtained by the advent of frost and cold dry weather, the disease perhaps persisting six or eight weeks. This is the experience of the father of the author. In many, perhaps a majority of cases, the advent of cough is accompanied by asthmatic symptoms of more or less severity, beside which every other discomfort pails. Indeed, more harrowing asthmatic manifestations than accompany this malady are rarely or never witnessed.

[*] "Principles of Prac. Med." London.

[†] *Br. Med. Jour.*, June 16, 1888.

[‡] *Ibid.*

[§] *Br. Med. Jour.*, June 23, 1888.

[‖] "Asthma," by Hyde Salter, London.

[¶] Vol. clvi., p. 583.

[**] *Br. Med. Jour.*, June 23, 1888.

[††] "Paroxysmal Sneezing," by Sidney Ringer and Wm. Murrell.

"Hay" asthma is apt to exhibit many vagaries. It may be absent one year, only to recur the following season with redoubled severity, from some specific cause or extra irritation. Usually it supervenes between the 25th of August and September 1, first manifesting itself after a severe fit of coughing, change of wind and weather, or from some unusual exertion such as running up stairs, and is a source of greater or less torture and torment until dissipated by cold weather or other atmospheric changes.

There is always manifest difficulty in breathing, accompanied by true asthmatic gurglings or râles, though exploration of the chest by means of percussion reveals nothing more than increased resonance, indicative of the presence of air in the intercellular lung tissue, while the ear detects dry, cooing, sibilant murmurs forcibly suggestive of a "kist o' whistles;" in fact, these sounds are frequently clearly audible at considerable distance, and greatly intensified upon the approach of a paroxysm, of which, in connection with increased difficulty in breathing, they give warning.

Those who have never seen or felt these paroxysms can have no idea of their severity. It is impossible for the sufferer to find any position of comfort or relief; he cannot lie upon his back, or even recline in an easy chair. Whether sitting or standing, and wherever overtaken by the paroxysm, he seeks a firm object on which to lean his wrists or elbows, and gasps for breath. Now the sonorous chest sounds gradually subside, while inspiration becomes inaudible and lengthened, and expiration correspondingly shortened and hurried. He is quickly all but overcome by exhaustion, but the struggles in effort to secure the desired supply of oxygen are unrelaxed, since they are to a certain extent involuntary.

This may last for a period varying from a few moments to hours, and relief is obtained only as the wheezing sounds again assert themselves, being accompanied by less hurried respiration and mitigation of the feeling of impending suffocation. If the improvement is not interrupted by another paroxysm, the expression of relief replaces that of suffering and anxiety, and the unfortunate is apt to fall asleep without much care or reference as to position, place, or comfort.

Many causes operate to produce these conditions. A well understood physiological fact is that an inflamed condition of the mucous membrane in one portion of the body excites irritation in the same tissues throughout the economy generally: consequently the catarrhal condition that obtains to the nasal passages—it often seems to commence with the conjunctival membrane of the inner corner of the eye—creates disturbances by sympathy and extension that, to the uninitiated, seem phenomenal, if not impossible. It is by such extension that asthmatic and bronchial phenomena are induced, and in like manner the ears, digestive tract, and urinary passages suffer. The father of the author suffers excruciatingly from this malady, and the first evidence of an inception of the asthmatic attack is derived from more intense itching and irritation at the inner corners of the eyes, with frequently manifest inflammation of the mucous membrane of the lids, including the outer eye tunic, and a perfectly maddening itching of the back of the soft palate, extending via the Eustachian tube to the ear. In one instance under personal observation, a more than usually severe morning paroxysm, such as is always apt to occur on rising, induced rupture of the capillary blood vessels in the lachrymal caruncle or prominence of the tear duct of the right eye, and caused engorgement of the organ and displacement of the visual axis, entailing double vision for some days.

Among the most marked results arising from this malady, also, are the direct and reflex changes in the vocal as well as respiratory apparatus, varying from loss of *timbre* and harshness to complete inability to utter the nasal vowels and consonants. The voice may further become husky or hoarse on account of the supervention of inflammation of the larynx from the action of cold and impure air during oral respiration, that speedily extends to the bronchi. Nasal obstructions, in short, seem to me one of the most important and generally overlooked causes of the attacks of bronchitis and asthma, acting either reflexly by causing dilation of the vessels of the bronchial mucous membrane, or by direct extension of inflammation. Voltolini's discovery that in certain instances nasal polypi had clear casual relationship to asthma has received such ample confirmation that its truth may be considered as indubitably established. More prolific even than polypi are the erectile tissue tumors, often so small that their existence remains unsuspected until made manifest by accident.

The area over the inferior of the top-shaped spongy (*turbinated*) bones of the interior of the nose, and the contiguous portions of the septum, by some are considered as most likely to induce reflex irritation, owing to the fact that here is present an excess of erectile tissue, though my own experience leads me to believe that the posterior part of the area, and the corresponding part of the septum, is chiefly at fault; irritation of any part of the mucous membrane, however, under certain circumstances may induce such phenomena.

Asthma and cough, then, are induced by mechanical irritation of a hypersensitive mucous membrane, which may be due to the presence of polypi, erectile tumors, or to thickening of the membrane such as is induced by the simpler form of "hay" fever, particularly when the position of the head is such as to permit occlusion of the cavernous sinuses and cause increased turgescence of the mucous membrane. This is most apt to occur in the lateral recumbent posture, and explains why these attacks, as well as the stuffiness of the under nostril, occur so frequently during sleep, and more especially toward morning. Sneezing and a copious flow of mucus from the nose usually precede or accompany these attacks of asthma and coughing: and sneezing in itself is a reflex act due to irritation of the fifth nerve; and while it may be induced by irritation of nerves in other parts, is usually of value as indicating the precise locality of the irritation of the nasal mucous membrane. The very fact of the simultaneous occurrence of hypersensitiveness of the nasal mucous membrane, such as always occurs in "hay" fever that is accompanied by cough, asthma, or bronchitis, inculcates the necessity of a careful examination of the nasal cavities before undertaking any radical measures of treatment. It is not always possible to say whether this casual relationship obtains in a given case characterized by the presence of both pulmonary and nasal disorders, but it is in favor of its existence if the symptoms alluded to precede the respiratory attacks, or if mechanical irritation of the nasal mucous membrane at other times than during "hay" fever indicates hypersensitiveness, and more so if it invariably provokes a reflex act, such as cough or prolonged sneezing. A nervous basis is probably an important element in most of these cases, for not a few are manifestly hysterical, or of hysterical origin.

One thing that markedly distinguishes "hay" fever from other catarrhal maladies of similar nature is its geographical relations. It does not exist over the whole of the United States or Great Britain, yet it is a matter of difficulty to attempt to define its exact limits. Numerous portions of England are immune, especially the high land and sea coast and all or nearly all of Wales and Scotland. In America it obtains to the north of Lake Ontario in limited degree, but not on the upper side of the St. Lawrence; scarcely at all in the province of Ontario north of the Welland canal, until the Detroit river is reached, and is wholly unknown to regions above the outlet of Lake Huron. In Michigan, however, it follows Lake Huron to above Saginaw Bay, finding victims even at Alpena, though residents of Cleveland, Detroit, Port Huron and Saginaw are here usually immune. On Lake Michigan its effects are lost above Ludington, while over on the Mississippi, in Wisconsin, it is felt as far north as the junction of the Chippewa, and in some seasons extends in a mild form to St. Paul, Minnesota. To the south it extends to the latitude of Memphis in the west, Knoxville in the central area, and Cape Henry on the Atlantic. In all this area there are immune districts at high altitudes, such as the Green, White, Adirondack, Alleghany and Catskill mountains, and the southern New York region. Isolated spots where the malady prevails are found about Galveston, Texas, St. Augustine, Florida, Montgomery, Alabama, and Milledgeville, Georgia. Beyond the Mississippi, evidence and data are almost wholly lacking, but several persons have suffered at Denver, Colorado Springs, and Golden City.

I now come to the most important part of this paper, the relief and palliation of the malady. Yet when one considers in detail all the facts and theories embodied with a view of formulating an intelligent plan of treatment, he finds himself encroaching upon most difficult ground. Not the least of the trouble is the fact there are at present held by authorities two more or less opposing views as to the causative significance of nasal disease in "hay" fever. Certain authors and specialists, as Hack,[*] Daly,[†] Roe,[‡] Bosworth,[§] Sajous,[‖] etc., insist that some nasal abnormality or deformity is always present, inducing the attacks. But here, one may ask with P. McBride:[¶] "What is a normal nose?" "The question may appear absurd," he adds, "but I am willing to run this risk if, by putting it forward, I can do a little toward moderating the enthusiastic zeal with which certain surgeons attempt to alter the nasal apparatus of their patients in conformity with what each individually deems an ideal normal nose. For ten years I have examined the noses of all cases of middle ear disease that have come under my notice, in private, hospital, and dispensary practice, and have found that even when changes are present that to the specialist's eye would appear very grave, the patients frequently suffer no untoward or unpleasant symptoms—that in a large number of cases, marked changes may exist without the presence of discomfort referable to the nose; and these lead me to believe that deviations from normal are by no means always to be regarded as fair game for the operator."

I re-echo Doctor McBride in the belief that in "hay" fever no supposed abnormal condition of the nasal passages should be regarded as a cause, when persistently present in otherwise healthy individuals, without reference to season or time, and that at other times than the "hay" fever season induce no discomfort. More than one sufferer has had occasion to bewail the loss of the special sense of smell owing to such interference, and without any definite mitigation of his malady. Nevertheless, there are instances as well, where cauterization or excision of the sensitive areas of the nasal passages is of decided benefit, of which more anon.

It is perhaps needless to remark there are no absolute cures for "hay" fever except removal outside of the areas where the malady obtains; that is to say, apparent cure in one year is no evidence of non-recurrence the year following; and the remedy that was efficacious one season may prove wholly inert the next; or that relieves one individual to-day is totally inadequate to the needs of another to-morrow; in fact any form of treatment where attempt is made toward general application is sure to illustrate the correctness of the old proverb, "What's one man's meat is another's poison."

Theoretically, the objects to be achieved are threefold: The soothing and strengthening of the general nervous system, the allaying of local irritability, and the removal of the exciting cause. The two former are of course palliative chiefly, while the latter [and to a certain extent the first may be conjoined] presupposes radical relief.

To remove the exciting cause, or, to speak more properly, to remove individual susceptibility, is to pre-

[*] *Wien. Med. Wochen*, August, 1883.

[†] *Med. and Surg. Reporter*, December 20, 1884.

[‡] *Archives of Laryngology*, vol. ii.

[§] *Jour. of the Am. Med. Association*, 1884.

[‖] "Hay Fever," Philadelphia, 1885.

[¶] *British Med. Jour.*, September 15, 1888.

vent the recurrence of the paroxysms, for which there is but one definite remedy, viz.: Removal to regions outside of the "hay" fever zone. Unfortunately, however, there are many who cannot avail themselves of this advice, and who, consequently, must be ever subject to the exciting causes of the malady.

Under such circumstances the most pertinent suggestion is to follow the approved rules of hygiene; avoid as far as possible conditions that tend to aggravate, notably mental weariness and worry, which are far more potent factors than commonly supposed; and to attend strictly to the maintenance of general health, strengthening as far as possible, by tonics and other means, the weak and irritable constitution. Indigestion, commonly termed "dyspepsia," is a most potent cause in many instances, and proper food, properly digested and assimilated, has permanently relieved more than one apparently confirmed "hay" asthmatic. Sir Morell Mackenzie* seems to place great faith in the employment of valerianate of zinc and asafetida as a tonic, nervine, palliative treatment, but I must acknowledge to have never seen any other result accruing save, as in Mark Twain's classic case, securing to the patient the "odor of a turkey buzzard." To the same end, and also with a view of producing an alterative effect, Dr. Chas. Blackley† recommends iodide of potassium with corrosive sublimate, which has been tried as a forlorn hope by many, with no better effect than a vile taste in the mouth. Arsenic, iodine, quinine, atropine, the bromides, grindelia robusta, antipyrin, iodoform‡ and the Lord knows what beside—pretty nearly everything in the materia medica, in fact—have been employed, only to mete out disappointment. However, tonics and alteratives are often valuable adjuncts, and so too are saline laxatives, and the "hay" fever ridden unfortunate will ofttimes obtain in connection with local applications decided assistance by the use of Hunyadi Janos diluted with pure water and drank hot immediately upon rising. Such narcotics as belladonna, stramonium, opium, etc., singly or in combination, are much lauded, and may give partial relief while one is under their immediate influence, but the dangers and drawbacks are such that the malady is a preferable choice.

Local applications are as a rule somewhat more successful as palliatives. "Hazeline," or extract of witch hazel, anthoxanthum and other tinctures of homeopathic origin, based on the imaginary law of similars and belief in dynamic therapeutics, have been widely puffed and advertised by dealers and manufacturers with all the zeal of that philanthropy which has for its inception a plethoric pocket book; but are all next to useless unless combined with strong *faith cure*, are very painful if employed undiluted, and wholly valueless when mixed with water. Muriate of quinine taken internally is sometimes of benefit, especially if combined with *dark* euonymin, from its effect upon the secretions of the economy at large, but employed as a snuff, or in an ointment, quinine in my experience always appears to aggravate the trouble. Chloroform, or chloroform spirits, is the sheet anchor of many of my acquaintances, and causes much mirth among ribald friends when the unfortunates copiously besprinkle their pocket handkerchiefs from a bottle constantly carried in the pocket. Were there no other remedy this would be a great boon, though there are many unpleasantnesses connected therewith, notably its bad effects upon the nervous system.

Iodine as an inhalant affords some slight relief in many cases, but not near so much as a bottle of strong smelling salts, made with carbonate of potassium and glacial acetic acid, to which a few drops of Parke, Davis & Co.'s antiseptic cologne is often a decided addition. A good snuff with many people cuts short the paroxysm at once, but the salts must be as *powerful* as they can be made. I would suggest iodide of ethyl also, as a decided means of relief for those who bear iodides well and suffer from "hay" asthma.

Cubeb cigarettes are also very comforting; indeed, if one be smoked in a small room and the doors and window kept close, tolerably complete immunity for the time is assured.

The remedial powers of arsenical preparations, both locally and internally, have been widely vaunted, but I can only say that none have ever seemed to me to have had the least influence, though I doubt not that Fowler's, Pearson's, or Donovan's solution, taken thrice daily, *after* meals, in as large doses as can be borne without absolute nausea, may ofttimes prove valuable adjuncts to local remedies, especially the Donovan, Hunyadi Janos water being employed as well, every morning on rising.

Dr. Carl Genth [*British Med. Journal*, June 16, 1888] insists that almost complete immunity may be had by bathing the mucous membrane of the eyes and by employing as a douche and gargle a solution of corrosive sublimate in the strength of 1 in 3,000. My personal experience does not in the least corroborate this, and a better preparation for the same purposes is a saturated solution of borax in camphor, or chloroform water, which may also be intensified by boric acid if desired,§ and carried in the pocket and snuffed up the nose *ad libitum*. Its soothing effect upon the mucous membrane is frequently almost magical. Bicarbonate of soda in simple solution, employed in the same way, has been suggested by Dr. Newton,‖ but is not nearly so good as the biborate [borax], or even camphor water alone.

Still another remedy that promises to be useful is peroxide of hydrogen¶—the "Golden Hair Dye" of the *nymphs du pave*—but must be employed with caution, since if it comes in contact with the beard or mustache, an intense yellow hue results, and a dark-browed, vindictive man, six feet four in stockings, wearing a canary bird moustache, is an object of by no means a pleasant contemplation for a small-sized doctor of timid or pacific tendencies! A fifteen volume preparation used in full strength, or diluted with water, as occasion [depending upon the sensitiveness of the mucous membrane in the individual] may demand, if sprayed gently through the nasal canals, will cause the patient to snort and blow the froth from his nostrils, expelling the dissolved mucus, when the application

* "Hay Fever," London, 1884.

† *London Lancet*, August 27, 1881.

‡ G. Hunter Mackenzie in *Br. Med. Jour.*, June 16, 1888.

§ Boric acid added, permits a greater addition of borax.

‖ *Cincinnati Lancet and Clinic.*

¶ Suggestions of Dr. Robt. T. Morris, of N. Y.

should be repeated, and again and again, in the same manner, until the nasal membrane is thoroughly cleansed. Next a spray of four per cent. solution of cocaine may be employed for the purpose of temporarily depleting the swollen capillary vessels of blood, when the entire irritated surface should be touched by means of an applicator [a brass annealed wire bent to an angle of 45°] wound with absorbent cotton dipped in a mixture of hydrastis, and boro-glycerin, diluted with three times its volume of Price's glycerin. This is by far the best treatment I have found except, perhaps, that indicated at the conclusion of this paper, and is in many instances successful in wholly relieving the patient of his malady after three of four applications; the first two or three times, it should be employed by a physician familiar with the use of the nasal speculum and rhinoscope, in order that every portion of the throat and nose may receive the application. Meantime the borax-camphor water should be employed for frequent washings of the eyes by means of an eye bath; likewise smoked glass "goggles" will be found of great aid and benefit.

Tobacco smoking pushed to the point of nausea, and the use of strong, clear, black coffee, are equally efficacious remedies, oftentimes, with those who are not accustomed to these luxuries, but both fail as soon as one becomes in the least habituated to their use.

The first and foremost of palliatives, however, is cocaine. I first employed this remedy three or four years ago, but abandoned because its effects appeared to be so extremely transient. Subsequently I had reason to believe the fault lay with the drug, and so began experimenting with Parke, Davis & Co.'s and Squibb's cocaines; and only those who have personally tried different preparations can justly estimate the immense difference that exists between these products and the article usually supplied by druggists. My experience, briefly, is that so far as the effects upon the nose and eyes are concerned, the two former are almost perfect, and will enable the sufferer to pursue ordinary avocations in comfort. One sufferer last year wrote, "With the assistance of a small bottle of cocaine solution, four per cent., and an inhaler, and armed with a pair of smoked 'goggles,' I have been able this summer to do what I have never before succeeded in doing, enjoy regular bicycle runs without any inconvenience worth speaking of. Without the cocaine, this would have been a physical impossibility for me, as, apart from the constant sneezing, the eyes become, when not under the influence of cocaine, and even when protected by large glasses, so swollen and suffused, by the rapid movement through the air and dust, as to render one almost blind."

Mr. John Watson,* of Westminster Hospital, London, who suffered to such degree during the summer months that any form of labor, physical or mental, was impossible, and who only experienced relief, strange to say, in the atmosphere of the theater, derived great benefit from "tabloids" of cocaine which he introduced into each nostril, pushing them well up with the tip of the little finger; undoubtedly the tablets intended for the hypodermic syringe would be equally effective.

Sir Andrew Clark† records his preference for cocaine bougies made of gelatin and glycerin, each containing one-fourth grain of the alkaloid; and also a mixture of glycerin and carbolic acid, each 8 drachms, with muriate of quinine, 1 drachm, and 1-2000 part of corrosive sublimate—the whole mixed by the aid of heat and applied by means of a mop to the inflamed and irritated nasal tissues. The effect of the latter is, he says: "Sometimes *nil;* sometimes gives relief for half an hour, sometimes for a whole day, and sometimes for the entire season." About one-half his patients were relieved for the season, and four permanently cured. He also advises, at the same time, the administration internally of alkalies and arsenic. The experience of one patient with this treatment is perhaps worthy of recording. He writes characteristically:‡

"Well, I have tried the mopping mixture, and as the chemist said who made it up, 'It's a powerful compound.' The first brushful on each application is very fiery to the nose, but strange to say, succeeding brushing in the same nostril is not felt, and one imagines all is going to be 'jam.' It isn't. I used it on going to bed, and it kept me awake half the night applying the 'kerchief' continual, like Androcles and the lion at the wax works. Also it was very fiery. Nevertheless, as with mixture before, I have no doubt it is a 'blessed cure.' I used it four alternate nights—24th to 30th—during which time I was tormented more or less, less on the 1st, so I thought I would give it an extra day's grace; this was Sunday, the 3d, when I spent the whole of the afternoon in the broiling sun of one of the hottest days we have had this year. But I felt no ill effects, and this was an exceedingly severe test. A fortnight previously, on a similar day, the sun brought out a frightful attack, and I could scarcely see where I was walking. This last week I have felt very little indeed of it. Got amongst some straw and dust Friday, which set me sneezing, but this soon passed away, and I think it unnecessary to mop any more. Next year, if I am a victim, I will start this mopping business on the first symptom of attack. I had given this to the 25th to exhaust itself, but now (the 11th) it appears almost done."

A four per cent. solution of cocaine in distilled water, which may require to be increased to five per cent. toward the end of the season, may be employed. When necessary, four or five drops are poured into the palm of the hand, and snuffed up into the nostrils by throwing the head slightly backward and from side to side, when the fluid may be made to practically reach all parts of the cavity: though some spray apparatus, such as Semple's inhaler, is much more convenient and certain. At the same time, by moistening the tip of the little finger, a drop or two may be introduced into the inner corner of the eye, with manifest relief to the "needles and pins" sensation. For the first few weeks of the season immunity is secured by this method, even in severe cases, for two or three hours; and as the effect of the remedy wears off, it should be reapplied.

If cocaine only had its local effect, there would be very little more to say than, "A palliative is at hand which for all practical purposes is perfect." But there is unfortunately another side to the picture, since, be-

* *British Med. Jour*, June 23, 1888.

† London *Lancet*, vol. 1, 1887, p. 1170.

‡ *Br. Med. Jour.*, July 23, 1887.

sides its local effect, the drug is a powerful nerve stimulant. I am not now, it must be understood, referring to the untoward effects induced by a single dose owing to the idiosyncrasies of individuals, but from continued use.

During the first few days the effect is ordinarily delightful; within a minute or two after absorption, all sensations of bodily or mental fatigue are removed, producing apparently a most pleasurable capacity for work; nevertheless, it will be found impossible to perform any act that requires great concentration and mental effort—the mind wavers, becomes uncertain, and suddenly the "hay" paroxysm unexpectedly asserts itself: meantime there is very little appreciable reaction. After a short time, however, conditions change: The drug acts less satisfactorily, requiring stronger and more frequent applications, coupled with great reaction—if one has an excess of work, the prostration incident to reaction is very severe; the appetite is decreased; sleeplessness induced; the heart's action rapid and unsatisfactory; and the whole nervous system brought into a highly strung, over-wrought condition. This is not in the least an over-drawn picture, and so strongly has it been impressed upon Mr. Bertran Windle,* of Queen's College, Birmingham, an intense sufferer from "hay" fever, that he last year declared himself in these words before the Birmingham and Midland branch of the British Medical Association: "In spite of the great annoyance and suffering produced by the malady, and the relief afforded, I am very doubtful whether I shall venture to run the risk of using cocaine another season. I can readily understand from my own experience what is meant by 'cocaine habit,' and I lay my views before the brethren in the profession as a warning against the rash use of the drug. I should say the lesson I have learned is, that whilst cocaine as a remedy affords palliation, perfect for all practical purposes, it is a drug whose use is accompanied by so many collateral disadvantages as to make it very doubtful as to whether its continued exhibition, during five or six weeks, is a line of treatment which is safe or justifiable to enter upon."

I had intended to ignore the drug known as analgesin or antipyrin entirely, but on second consideration I will state the facts connected therewith. Like chloral and some other remedies, it often has a decided soothing or anæsthetic effect upon the mucous membranes of the body when taken internally in large doses, but it is an unsafe remedy, frequently inducing profound and dangerous collapse by its interference with the heart's action:† especially is this true of Knorr's antipyrin.

There are two remedies, however, that may be employed to replace cocaine, and successfully in most instances, viz., brucine and menthol. The former will give all the soothing effect, while the latter may be employed to continue it.‡ A camphor water, two to five per cent., solution of brucine is perhaps best, while the menthol may be employed as strong as can be borne, or as required to meet the indications in the individual. Both are safe and in no way tend to habituation: and as aids I would advise the Hunyadi Janos; quinine and euonymin, adding perhaps hydrastis; simple but liberal diet, with but very moderate indulgence in malt or spirituous beverages; and as perfect freedom from mental worry as possible. That paroxysms may be repressed by mental effort, on occasion, is not to be doubted, and with many, immediate amelioration is had by retirement to a dark room.

Again, those cases in which there is decided swelling and thickening of the nasal tissues are effectually treated by caustics oftentimes—by the application of the galvano-cautery heated to cherry redness, or by touching with glacial acetic acid. A still milder measure, and one that is practically painless, is recommended by Dr. W. H. Daly,§ of Pittsburg, which consists of the local abstraction of blood from the swollen tissues by means of a small, fine knife, similar to that employed for incising the cornea in the extraction of cataract from the eye. I have had no personal experience with this, but it certainly commends itself, as does any method that will permit of restored free nasal respiration and reduction of sensibility in the hypersensitive areas of the parts. Sneezing paroxysms that terminate in hemorrhage are almost invariably followed by relief. Indeed, I am inclined to believe that free application to sensitive area of the inferior turbinated bones and posterior portion of the nasal septum will permanently relieve "hay" fever, from the fact that one patient who suffered thus before the growth of polypi was entirely cured by the subsequent removal of these growths, and another obtained equal immunity by an injury that caused extensive ulceration and sloughing of the posterior border of the nasal septum. Probably, also, in many instances, the daily application of Sir Andrew Clark's carbolic-sublimate mixture for some days prior to the onslaught of the malady will prove effective for that season, or so nearly so that merely a mild menthol spray, employed after a thorough douching, will be entirely satisfactory. At the same time the mucous membrane of the inner corners of the eyes should be carefully washed every morning with soft water, and thoroughly saturated afterward with a mild solution of corrosive sublimate [1 to 3,000] or borax in camphor water. Where the disease affects the ear also, the Eustachian tube and middle ear may be inflated by means of Politzer's inflation apparatus, with the vaporizer attached containing spirits of chloroform. By such measures, one may confidently expect relief consistent with tolerable comfort, and sufficient to permit attendance to ordinary daily occupation, and above all relief from that peculiar feeling of aprosexia, or mental lassitude, that constitutes inability to fix the attention upon any one subject, and which is so constantly a concomitant of this malady.

English gold coin is so depreciated by wear that a banker who recently accepted £1,000 in gold half sovereigns, upon depositing it found it short weight by £19.

* *Birmingham Med. Review*, Dec., 1888.

† *The Practitioner*, London, 1888.

‡ There is a third drug, *caffeine*, that promises apparently to be even better than cocaine or brucine, though my personal experience therewith has not been sufficient to warrant any very positive assertion as to its value. It is certainly worthy of extended trial.—Author.

§ *Med. and Surg. Reporter*, Nov. 17, 1888.

SEPARATION OF COPPER FROM LEAD, CADMIUM, MAGNESIUM, MANGANESE, MERCURY, ZINC, ETC.

By G. VON KNORRE.

THE metals must be present as sulphates or chlorides. The solution, which, if necessary, is reduced to a small volume by evaporation, is neutralized with ammonia if free mineral acids are present, and acidified with a few drops of hydrochloric acid. It is then heated almost to a boil, and there is added an excess (five parts to about one of the copper present) of nitroso-β-naphthol, previously dissolved in boiling acetic acid at 50 per cent. It is convenient to filter the hot solution of nitroso-β-naphthol through a moistened filter and let the filtrate flow into the hot solution containing the metals, stirring meanwhile. After the liquid has stood for some hours in the cold the copper nitroso-naphthol is filtered off and washed with cold water until a drop of the filtrate, if evaporated on platinum foil, leaves no solid residue. The washings, even then, have a yellow color which does not affect the results. When dry, the filter and precipitate are placed in a capacious tared porcelain crucible, the filter is closed, the crucible is loosely covered, placed upon a sheet iron plate, and cautiously heated with a small flame until vapors no longer escape. The temperature is then gradually raised, and the crucible is finally ignited with access of air until the carbon is burnt off, when the copper oxide can be weighed. If the quantity of copper nitroso-naphthol is considerable, pure oxalic acid or ammonium oxalate should be added to the precipitate on incineration in order to secure quiet decomposition. In presence of silver the copper precipitate is argentiferous.—*Zeitschrift fur Analytische Chemie.*

[Continued from SUPPLEMENT, No. 711, page 11361.]

ON THE ACTION OF LIGHT ON ALLOTROPIC SILVER.

By M. CAREY LEA.

SINCE my last communication to this *Journal* I have obtained the following results:

1. It was mentioned in that paper that the red gold-colored modification of silver was converted into a bright yellow-colored form by the action of light. Continued exposure seems to produce little further change so long as the substance is dry. But if the paper on which the silver is extended is kept moist by a wet pad, with three or four days of good sunshine the change goes on until the silver becomes perfectly white, is apparently changed to normal silver.* Water, alone, tends to darken this form of allotropic silver. Accordingly, the portion of the paper that was protected for comparison darkened, showing that the whitening effect was due wholly to light.

It thus appears that light can convert yellow or red-yellow allotropic silver to white.

2. Some pieces of very bright blue-green modification were exposed to light, and with about one day's bright sunshine they passed to a pure bright metallic gold-color.

It appears therefore that light can cause the blue-green modification to pass to the gold-yellow.

This change only occurs with a very brilliant form of the bluish-green substance which is obtained with a quick, short washing. Specimens slowly and very thoroughly washed, which when brushed over paper gave a more mat color, did not yield this result, but became brownish, as described in the July number of this *Journal*. Nor can this result be obtained with the soluble form of allotropic silver described in the June number of this *Journal*.

Light therefore can change the bluish green to the yellow modification, and this last (with the aid of moisture) to white normal silver. The silver thus obtained is pure white, lustrous, and metallic, resembling silver leaf. Organic compounds of silver reduced by light give gray or black silver devoid of luster.—*Am. Jour. Sci.*

THE REACTIONS INVOLVED IN THE CALCINATION OF PORTLAND CEMENT.

MR. B. H. THWAITE, C.E., contributes to the *Builder* the following interesting notes on the syntheses of the reactions involved in the calcination of Portland cement, the same being based on Le Chatelier's researches.

Our authority, having delivered himself of the opinion that no scientist has applied scientific reasoning to nor analyzed the development of the various actions occurring in many industrial processes with more thoroughness than Chas. Le Chatelier, goes on to say:

In the calcination of Portland cement, the first effect is the expulsion of the water at 100° Cent.

The next effect is the decomposition of the clay at a temperature of 600° Cent., and its dehydration.

Between 800° and 900° Cent. the calcic carbonate is decomposed with the expulsion of the carbon dioxide (CO_2). The calcic carbonate is then converted into quicklime.

This is an important phase in the calcination. Immediately the carbon dioxide leaves the lime the influence of the contact with the clay is accelerated, and the two agents, lime and clay, combine—the combination becoming more complete the higher the temperature, and the more it is prolonged.

The grains of lime and particles of clay form fusible amalgams of two kinds; one having a basic preponderance, the other an acid one. In any amalgam constituted of a piece of imperfectly calcined clinker, the center will be found to consist of the clay constituents, silica and alumina. Around this will be melted glass, or an excessive preponderance of clay, in a mixture of the clay and the lime. Next to this will be a melted mixture of the double silicates (silicates mono and dicalcic), both fusible at the ordinary temperature of calcination of the cements. Next to this last amalgam, and forming the more perfectly burnt part of the clinker, are the silicates of lime, the silicates tricalcic (infusible), and the aluminates of limes (fusible), and, finally, the quicklime.

The proportion of these various elements varies continually with the degree of advancement of calcination.

If there is a very considerable excess of the lime agent, the final product of calcination will be the silicate tricalcic and aluminate tricalcic along with quicklime; if the proportion of lime is not in excess, the quicklime will be absent if less lime is used, the calcic aluminate will disappear, and will be replaced by a double silicate, analogous in its composition to blast furnace slag.

If the proportion of lime is further diminished, the silicate tricalcic will disappear, and be replaced by the silicate dicalcic, and a further calcic reduction will convert the silicate dicalcic into the silicate monocalcic.

The following table illustrates the influence of an excess of lime on the character of Portland cement:

Normal cement.		Excess of lime.	
S_1O_2 = 1·00	1·21	1·00	1·17
Al_2O_3 = 0·21		0·17	
Fe_2O_3 = 0·04		0·03	
CaO = 3·29		3·71	3·76
MgO = 0·08		0·05	
CaO.SO_3 = 0·015		0·01	
Bases . . 3·37?	= 2·78	3·76	= 3·2
Acid . . . 1·21		1·17	

The analyses of cement should show that the cement has an excess of lime, or more than three equivalents of protoxide (CaOMgO) to one equivalent of acid ($SiO_2Al_2O_3$).

* The pad used was of unbleached muslin, which was boiled several times with distilled water to remove everything soluble before use.

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